INTEGRATED EDITION OF THE PETROLEUM ENGINEER

the Petroleum Engineer

FOR MANAGEMENT

JUNE 1958
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IMPORTS

TIPRO Symposium tackles baffling problem

Gas pipelines to spend 21% more in 1958

Dowell Guide to Acidizing

1. Paradox Lime
San Juan County, Utah

1. This formation is both vugular and highly soluble. Good results often occur after a wash of Mud Acid, followed by Retarded Acid or regular acid with surface tension and emulsion control agents added. Acid volumes range from 1500 to 10,000 gallons or more. *Wells often potential more than 1000 bopd.*

2. This vugular pay reacts quickly with regular acid. For this reason an acid with retarded action has been used. Typical treatment is 250 to 500 gallons regular acid containing surface tension, anti-emulsion and silicate control agents; followed by 1000 to 5000 gallons of the slow reacting fluid used in Acid Petrofrac®. *Wells producing from 16 to 45 bopd often increase to 80 to 125 bopd.*

2. Noodle Creek Lime
Jones County, Texas

3. Chester Lime
Beaver County, Oklahoma

3. Reaction time is usually less than one minute in regular acid. As a result, Retarded Acid is usually recommended. The following three-stage treatment has proved successful: (1) 500 gallons Mud Acid; (2) 500 gallons regular acid with surface tension and anti-emulsion agents added; (3) 5000 to 20,000 gallons Retarded Acid injected at rates up to 30 bpm. *Some previously non-commercial wells have potentialed 20 million cfd after treatment.*

4. This dolomitic limestone is found from 10,400 to 11,100 feet. Some sections have crystalline porosity. Some are fossiliferous, and some are vugular. Treatment with either 10,000 gallons Retarded Acid or 3000 to 20,000 gallons regular acid has been successful. A wash with Mud Acid ahead of the main treatment is recommended. *Wells have potentialed 300 to 500 bopd after treatment.*

4. Townsend Wolfcamp
Lea County, New Mexico

5. Many new wells in the Midale Beds get good drill stem tests, but produce only a show. Treatment is often a 500 gallon wash of Mud Acid followed by 500 to 2000 gallons Dowell regular acid with anti-emulsion, surface tension, and silicate control agents added. Injection pressures are held to 1000 psi or below to minimize water troubles. *After treatment, wells have potentialed 80 to 100 bopd*

5. Mississippian Lime
Southeastern Saskatchewan

6. This flashy formation reacts fast with regular acid, so Dowell has used Retarded Acid to increase penetration, drainage area and production. Typical treatment is 500 gallons Dowell acid with surface tension and de-emulsifying agents added, followed by 3000 to 4000 gallons Retarded Acid. *Potentials are often increased from a show to 240 bopd.*

With 41 different acid addition agents to choose from, Dowell engineers can help you "tailor" the best acid treatments to the requirements of your well. Call your nearest Dowell engineer. Let him tell you how Dowell acidizing services have helped other operators in your area get higher production from their wells. Have Dowell acidize your wells. Dowell, Tulsa 1, Oklahoma.

Services for the oil industry

DOWELL

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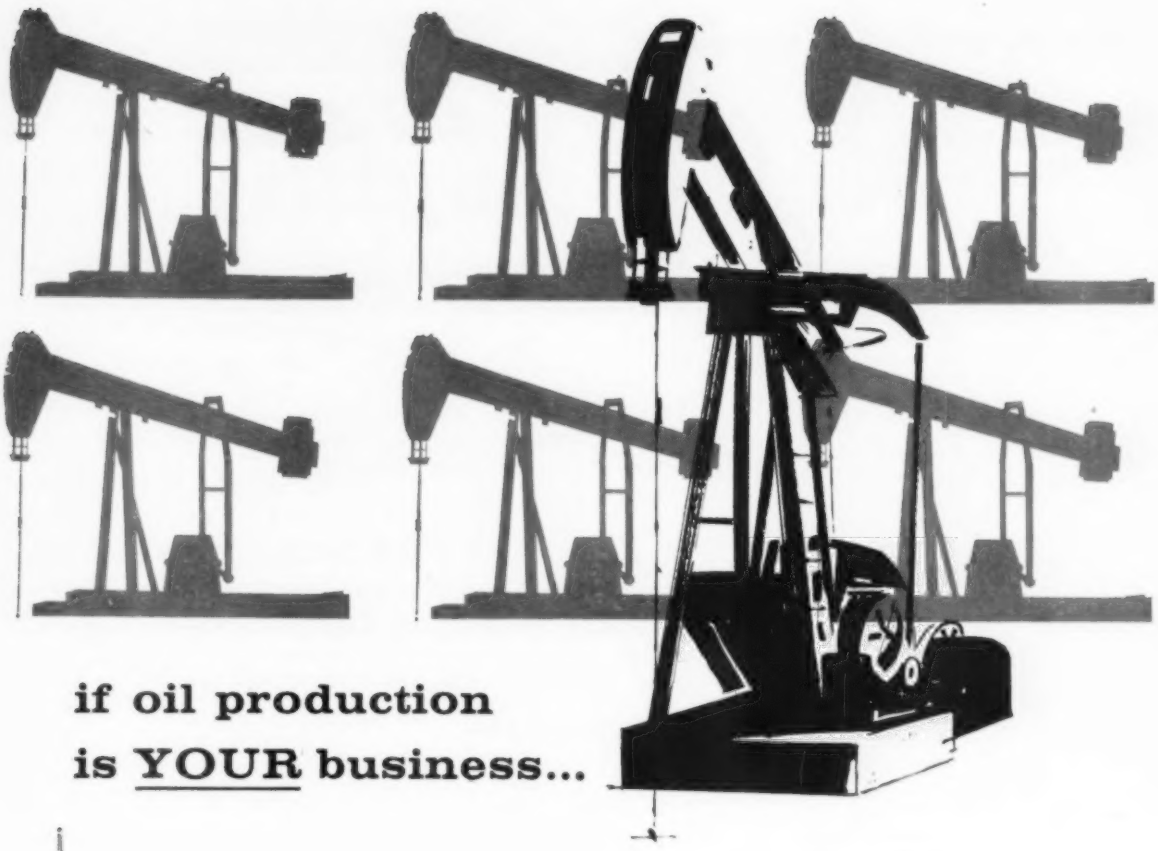
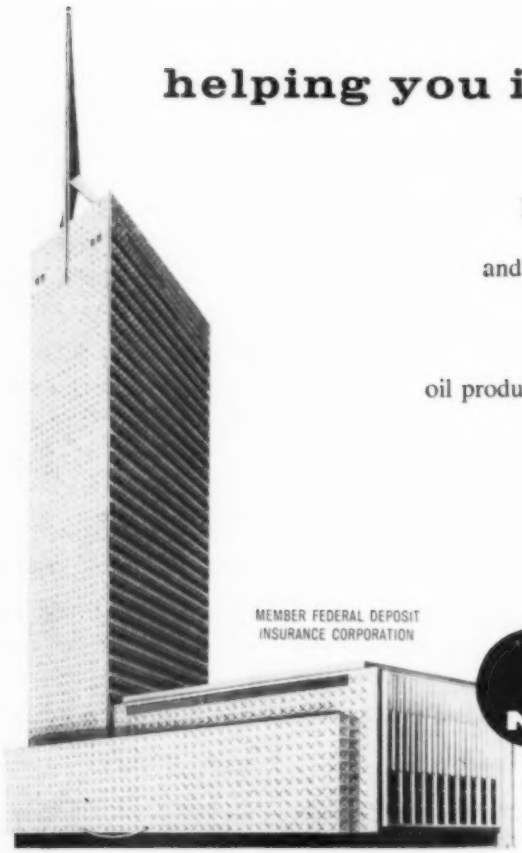
6. Lansing-Kansas City Lime
Barton County, Kansas



if oil production is YOUR business...

helping you is OUR business



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A Magazine of Petroleum Management

the Petroleum Engineer

FOR MANAGEMENT

NUMBER 6 • VOLUME XXX • JUNE, 1958

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— *Maurice Maeterlinck*

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Your Biggest Challenge

There are three fundamental ideas as to how we can improve our society:

1. *Create more.*
2. *Cut spending and live on less.*
3. *Divide the country's wealth.*

Which of these ideologies appeal to you most? Before you answer, perhaps you should give deep thought as to your reasons and to the consequences.

Whether we realize it or not, we have come a long way in the past 25 years toward the No. 3 idea. Heavier tax burdens on everybody, government subsidies, social benefits, unemployment compensations, and a host of other so-called "assistance" programs take away from the many to solve the individual problems of a few.

This country gained its wealth in economic freedom. It expanded opportunity until it reached out and touched more people than any social order ever devised. It is a system based on reward rather than penalties . . . we haven't attained our wealth by dividing it up . . . nor, have we come this far by standing still.

To create wealth . . . you must show confidence by investing yourself and your money. Our forefathers wanted more for themselves and for future generations. And that means creating more.

You can't build a nation, a state, a corporation, a small business or your individual status by standing still or by dividing up what you already possess. *To grow . . . we must create more,* not just more of the things we already have. To grow in a fast-moving technology, it takes new things to cope with new problems . . . new ideas . . . new energies . . . and above all . . . initiative.

In our petroleum industry, there are companies and individuals in all its branches that know their growth is based on creating — by improving what they have and developing new things. With that basic thinking they have developed an optimistic philosophy about the future. They forge ahead with plant expansion . . . continue the unrelenting search for more petroleum . . . expand research for better and cheaper things . . . develop revolutionary products and services. This takes courage, faith, a will to work for just rewards, and an ability to disregard failures.

The choice and the opportunity is not petroleum's alone . . . but all American enterprise. To have faith and confidence in the future . . . the will to create more: This is your biggest challenge.

J. E. Kastrop

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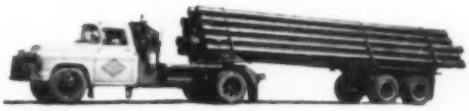

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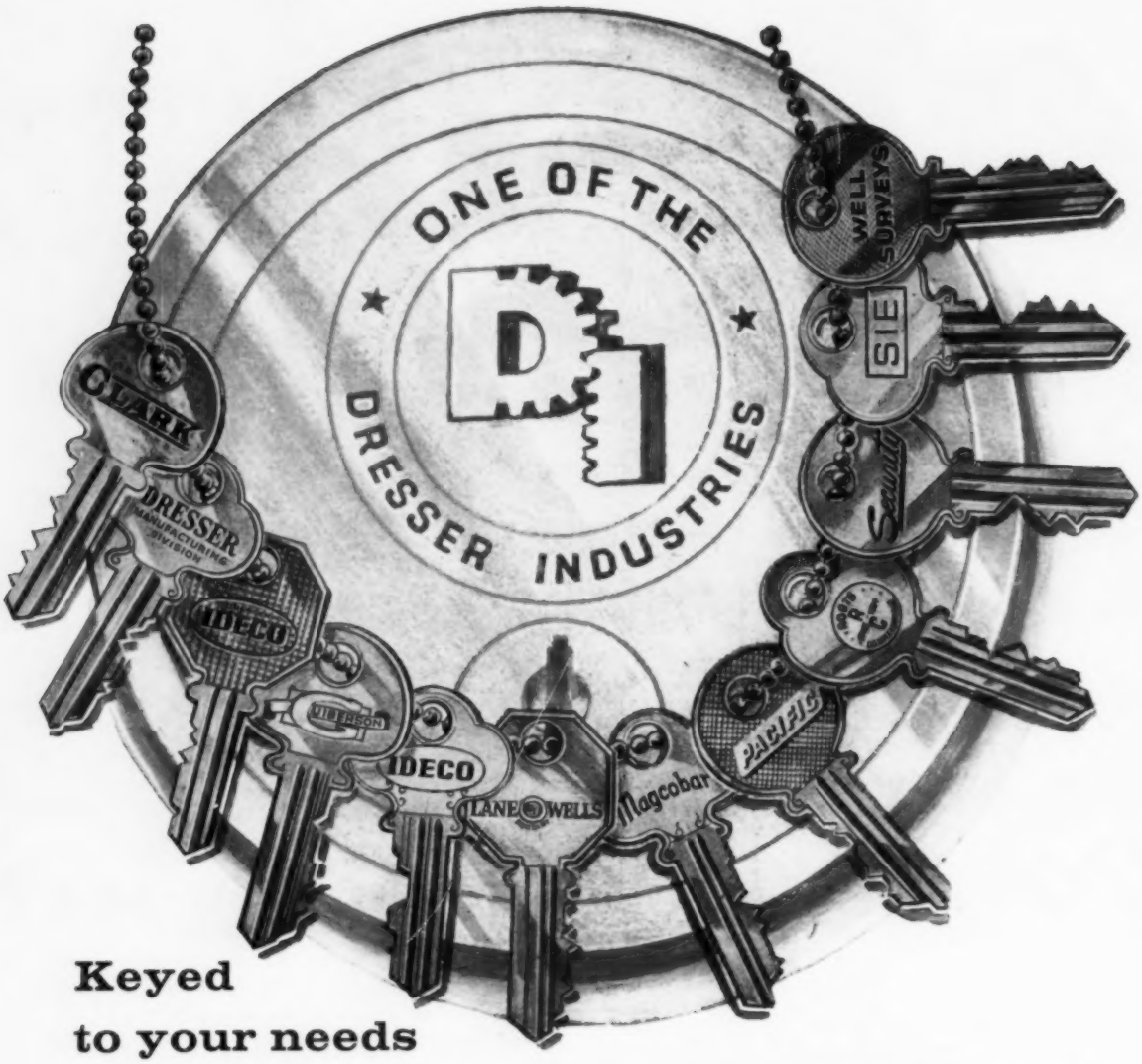

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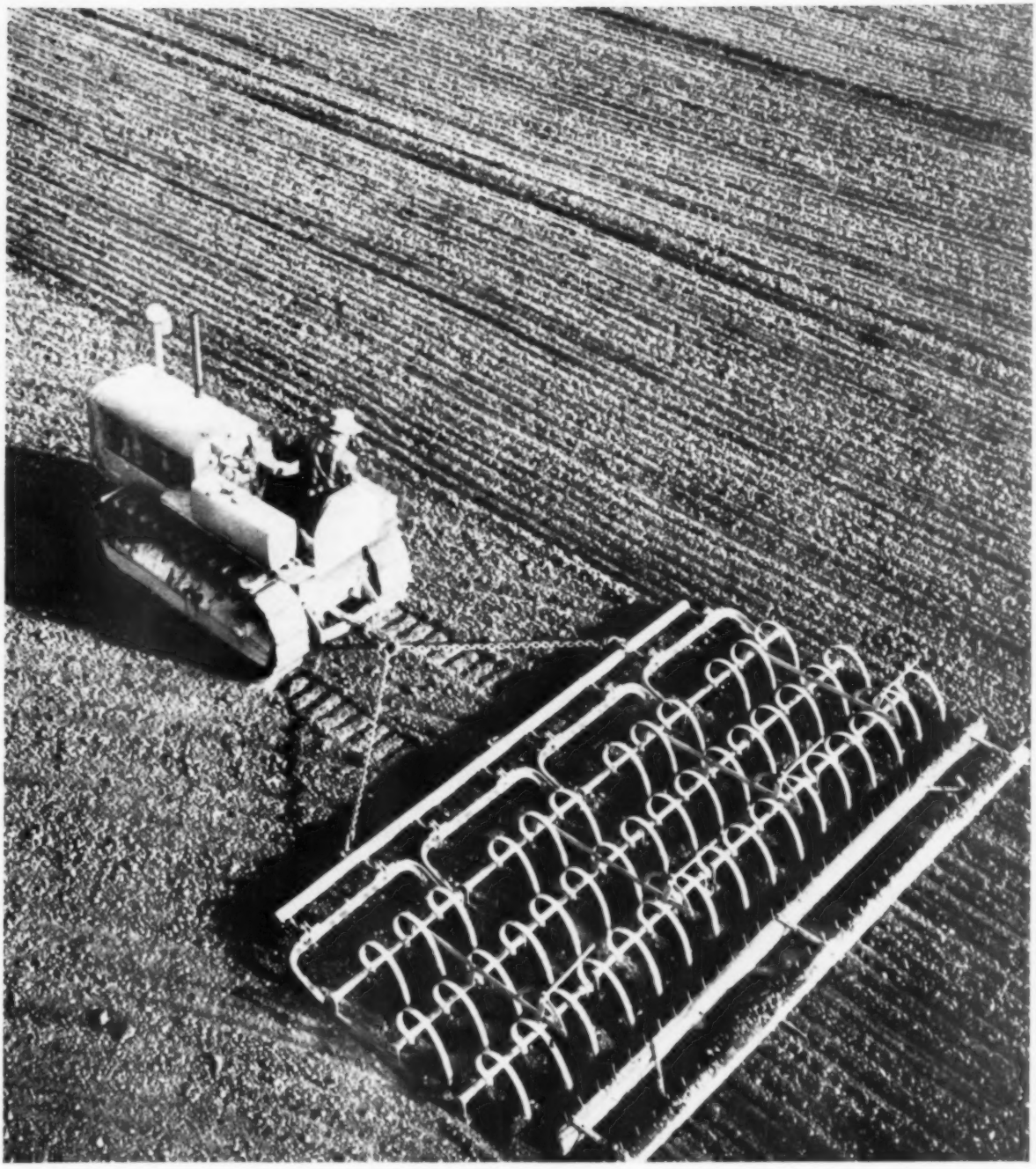

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—M. J. Rathbone, President, Standard Oil Company (New Jersey)

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The future is a world limited by ourselves . . . . . . MAURICE MAETERLINCK

From Your Point of View

Tom P. Walker, chairman of the board, Transcontinental Gas Pipeline Corporation gave his "Thoughts on Retirement" at the Southern Gas Association meeting in April. He had a refreshing approach.

His main theme was that 65 was a good age at which to retire. That you had a lot of years ahead of you and that you should quit while you're ahead! He thought a definite schedule better — to keep freshening management.

It is certainly true, too, as Mr. Walker said, that your approach to retirement rests with your own point of view. His grandson came up to him one day and said "Grandpa, your hair is turning black" and so it could be — if you looked at it that way.

Naval Reserves Again!

Just at the time when we have oil running out the ears of the world, the Navy has started working on the old Teapot Dome for more supply. Does anybody know why? You can buy oil much cheaper than the Navy can produce it at Teapot Dome.

If Congress could get in a bit of legislature that would bring in a few dollars, this would be a good way to do it — auction off the Naval Oil Reserves.

How to Write Your Congressman

1. **He shoud be addressed as Representative John Roe, or Senator John Doe — not Mister.**
2. **Be brief, but not terse.**
3. **Be specific, positive — don't hedge.**
4. **Give him the local viewpoint — how the national issue would affect your community, your industry, your businesses.**
5. **Letters should be dignified.**
6. **And reasonable — don't ask the impossible.**
7. **But request action — your Congressman was elected to do something.**
8. **Make it your letter — on your letterhead, in your style.**
9. **Request an answer — you've told him where you stand, now ask him where he stands.**
10. **Be appreciative — thank him for good things he does.**

Prepared January 1957 by Legislative Department, Chamber of Commerce of the USA

Want to Buy a Car?

Of the 11,785,000 cars produced in 1957 the USSR manufactured 114,000 compared to 6,113,000 in the United States. After USA, other leading manufacturing countries were Western Germany, 1,040,000; United Kingdom, 861,000; France, 738,000; Canada, 356,000; Italy, 318,000. The United States thus manufactures 55 percent of all automobiles produced in the world.

I've Grown Accustomed to His Space

Husbands are so ordinary, complains an Oil Wife. Hers is just plain standard dull: 42 around the waist, 38 around the chest, 92 around the golf course and a darn nuisance around the house.

— Canadian Petroleum Association Monthly Report

This Is Bad?

Gross national product — the sum total of all goods and services produced — was at an annual rate of $422 billion in the first quarter, down 4 percent from the record high of July-August-September last year.

Government statistics showed that the writedown in inventories in the first three months this year was the sharpest ever recorded. Best guess, was that inventories in many lines would be down to rock bottom in a couple of months.

Detroit, with 18 percent of its labor force unemployed, saw a record crowd of 13,513 flock to the opening of the Hazel Park Harness Raceway and bet a record $487,223.

Contracts awarded in April for future construction showed a king-sized gain over 1957 after trailing year-ago figures for the previous three months. Road building was one of the brighter spots.

National Association of Home Builders forecast a 10 percent increase in housing starts this year.

Consumers kept spending at a fast pace that almost matched last year's record rate.

Production of steel and automobiles, while still far below year-ago levels, moved up a bit.

Too Much Sesquipedalianism

We just can't get away from it. It seems to be a characteristic of a number of engineers. Maybe not the majority, but the more talkative ones. Lawyers go in for it, too. Maybe it's a professional trait. Oh, you don't know what sesquipedalianism is? It's the use of long words.

Productivity vs Wages

One of the reasons advanced for the present slow business activity is the increase of wages without sufficient increase in productivity. When labor costs rise employers must recover the higher costs by raising prices or his operations will become unprofitable. That is, competitors will keep his costs down until he cannot make a profit or the consumers will not buy when his product is marked with a high enough margin to make a profit. This brings on a business recession and unemployment.

In the petroleum industry labor costs are lower per volume of business than in nearly any other industry. This means very high capital invested per employee, and is the chief reason for the high productivity rate. The present recession, however, has made management very conscious of the need for more efficiency in business. Profits have been taking a beating and the oil industry must have good profits to keep up with the demands upon it.

For the first time in our 12 years of surveying annual reports there were several comments this year about the need for greater productivity or a slow-down in wage increases. Business has reached a point where it is hard to sell at a cost-plus price.

If you were in business for yourself

A look at our Company's financial statement in terms of one employee's portion helps us to understand what happens without becoming bogged down by ciphers

If you owned a business equal to one employee's share of Standard of California, it would have a book value of **$47,300**

(Socal's cash, plant and equipment and other assets less current liabilities and reserves ÷ average number of employees)

Now, assume you had run your business in 1957 as Socal did. Here's how you would have made out financially:

a) You would have sold products and services amounting to $42,100

b) Dividends from affiliated companies and other miscellaneous income would have brought in 2,300

c) Thus, total income for the year would have been **$44,400**

d) But during the year, you would have had to buy crude oil and process it. And you would have had to buy containers and other products, pay operating, marketing and administrative expenses including the salaries of yourself and the people who work for you. Then there would have been taxes. All told, this would have cost you **$37,000**

e) So your net profit would have been . **$ 7,400**

f) Now, assume you were set up in business as Socal is with all the assets of the company owned by stockholders. You would have paid them a return on their investment of $47,300. Assuming you paid them dividends at the same rate as Socal did last year, this would have been 3,100

g) This would leave you with . . . . **$ 4,300**

Now you have a big decision to make. *What to do with the $4,300. If you're like Socal, you'll come to the conclusion that you want your enterprise to be successful for a long time to come. You'll realize that you can't be sure of being in business in the future unless you're able to find more oil and keep ahead of competition in other ways. So you'll probably reinvest every available dollar in the search for more oil and in building modern equipment. This then is what would happen to your "profit" if you were in business for yourself.*

Reprinted from April, 1958, issue of The Standard Oiler, company magazine of Standard Oil Company of California; William H. Jones, Editor. The special issue, Report of Progress — 1957, was outstanding example of employee communication.

TIPRO Girds for Battle

Neville G. Penrose

Texas Independent Producers and Royalty Owners Association had a free-for-all forum at their annual meeting in San Antonio in May. We considered it interesting enough to publish a collection of papers given on the subject of "Imports."

There is certainly no question about how TIPRO stands on the problem. The organization has enthusiastically endorsed the Ikard Bill, which would limit imports to the 1954 proportion. Neville G. Penrose, Fort Worth independent and chairman of the imports committee, got unanimous approval of his resolutions favoring the Ikard Bill.

Imports are today's hottest subject. You'll be interested in reading six sides of the problem beginning on page E-2.

Educational Grants

There are so many companies giving grants to colleges and universities for scholarships, research, faculty, etc., that we have found it almost impossible to keep up with them and report them. Here comes one now that has just a little different angle. Creole Petroleum Corporation and the Creole Foundation announced grants of $36,700 to 34 U. S. universities and colleges where their scholarship students from Venezuela are enrolled.

Nearly 70 Venezuelans are currently enrolled in U. S. colleges and universities under Creole auspices. The company also awards 150 scholarships annually in Venezuela.

No "How"

Floyd G. Lawrence, editor of Automatic Machining, recently pleaded for more industry-wide information. "How much would you admire a man who told you that he had just invented the wheel?" he asked. "Maybe he did, but he sure wasted a lot of effort a little information would have saved him." Lawrence feels that the manufacturers of tools and equipment should give their customers every kind of information available about their products.

"Figuratively speaking, your plant and our industry often spend time just inventing the wheel," Lawrence said.

The direct approach, inter-plant communication of ideas, is not enough to eliminate pointless duplication of effort. It is through classes, field engineers, news bulletins, magazine articles, to name a few, that the information of the whole industry can be circulated to be used by the men who face the problems.

"We're spending too much time using know-how for no 'how,'" he concludes.

World Trade Boost

You don't trade only in goods, is J. B. O'Connor's message in the condensation of his speech on "How to Win an Economic War," pages E-34. When you sell, you sell a way of life. As the Dresser Industries president says, "Sell the whole package."

He gives five main steps in his method to achieve economic well being, but none so important as his idea that what we have to offer the world is more than Coca-Cola and nylons — that we must sell the means of preserving western civilization.

HIGHLIGHTS ★ ★ ★

Digest of News and Comment

Defense for Domestic Oil

Domestic oilmen received their biggest boost in months in a letter written by the Department of Defense, coordinated by Secretary Neil McElroy and cleared with the Budget Bureau. While the letter was for the purpose of aiding a bill aimed at 27½ percent depletion rates for oil shale, phraseology was such as to belittle foreign oil importance — in effect, a change in policy among defense officials. Letter suggested it would be "extremely dangerous" for the U. S. to rely on foreign oil.

Too Many Tankers?

For the fifth consecutive month, no orders have been placed for construction of oil tankers in American shipbuilding yards, reports Shipbuilders Council of America. Two tankers were launched in March and one was delivered. At the end of that month 71-oil-carrying vessels were on order or under construction in American yards.

Oil Congress Exposition Set

New York's Coliseum has been selected as the site for the Fifth World Petroleum Congress Exposition, scheduled June 1-5, 1959. Exhibit space is already being called for on two floors of the Coliseum. Over 70 technical sessions covering every phase of the industry will be conducted in conjunction with the Congress. More than 30,000 are expected to attend the Exposition and Congress sessions.

Military to Ease Oil Buying

The continuous nine-year rise in government oil purchases for the military may be expected to level off in 1959, states Rear Admiral O. P. Lattu, director of the Military Petroleum Supply Agency. Last year the government purchased $1.25 billion in oil products — about 7 percent of total U. S. production. Lattu indicated that military procurement of petroleum should reach a peak of 260,000,000 bbl next year, then begin a slight decline.

Independents Looking Abroad

Domestic oil problems are causing small oil companies to look beyond U. S. boundaries for new work, says John Padgett, technical manager of foreign operations of Halliburton Oil Well Cementing Company. Foreign oil operations are becoming more and more the field of small American operators, he declares, and they are being encouraged to look to these new areas because of U.S. taxes and costs of operation and rising oil demand abroad. Independents are now negotiating for exploration contracts in Lebanon, Syria, Pakistan, India, Sumatra, Jordan, Turkey, in the Persian Gulf, and in most Latin American countries.

The actions of a few can and do degrade an entire group. This is just as true in the oil industry. For this reason, THE PETROLEUM ENGINEER is presenting this appeal for aid in locating this individual.

WANTED BY THE FBI

Irwin Millner is being sought by the FBI for conspiracy to violate the Interstate Transportation of Stolen Property statute. He is alleged to have conspired with other individuals in the theft of geological and geophysical maps belonging to Gulf Oil Corporation.

A Federal grand jury in Pittsburgh, Pennsylvania, indicted Millner with conspiracy and a warrant was issued for his arrest on December 27, 1956. He has not been found.

Millner, alias Irving Millner, Irving Milner, and Fred Miller, reportedly has had considerable experience in the oil industry in both the U. S. and Canada. He has participated in many oil promotion and drilling ventures in the past.

He is described as weighing between 275 and 375 lb; is 6 ft 3-in. tall; has gray hair and brown eyes. He is said to comb his hair straight back and has a clean-shaven, round face with double chin. He wears heavy-rimmed glasses for reading and is said to have a very impressive personality.

Any person having information which might assist in locating this man is requested to immediately notify the Director of the Federal Bureau of Investigation in Washington, D. C., or telephone the special agent in charge of the nearest FBI division, as listed on the first page of local telephone directories.

Wants No Oil War

Japan wants no oil war with American or European countries arising from negotiations its companies are making with foreign countries, says former Japanese Foreign Minister Katsuo Okazaki. The former minister is a consultant to Japan's new Arabia Oil Company, which recently signed an agreement for offshore rights for Saudi Arabia's share of the neutral zone. He is now negotiating an offshore agreement with the British-protected Kuwait in England and states that his country wants to "work hand in hand with the world's existing oil firms."

Mississippi Hints New Tax

New taxes on oil and gas royalties and mineral rights have been recommended by the legislative council of the state of Mississippi. One of the bills would impose a $1 per acre tax on all oil, gas, and mineral rights owned in fee and separately from the surface estate, and 50 cents per acre on all royalty acreage exclusive of the surface estate. A second bill would levy a 20 percent evaluation tax on all royalty and overriding royalty payments from oil produced in Mississippi. A credit for oil severance taxes paid would be given and would not apply to working or leasehold interest in oil, gas, and and other minerals.

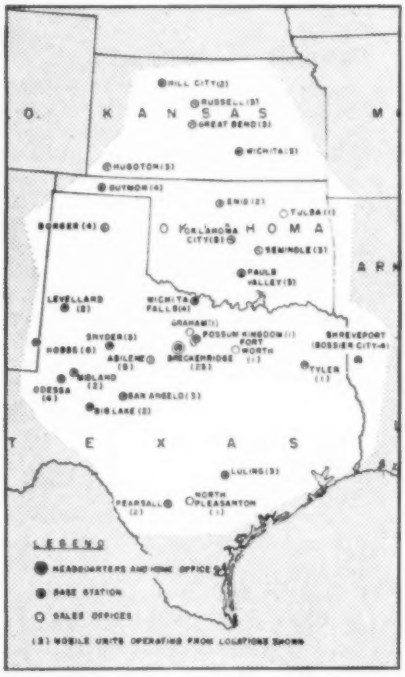
Hungarian Oil Still Lagging

Petroleum is the only major branch of Hungarian industry that has not rebounded sharply from low levels reached following the anti-Soviet revolt in October-November 1956. Russian reports show that Hungarian oil output was 407,000 bbl in November 1957 — the same as in January 1957. The annual production rate of 4,884,000 bbl indicated for 1957 on the basis of the two months cited compares with 8,724,000 bbl in 1956 and 11,639,000 bbl in 1955.

No Longer 'Orphan Annie'

Asphalt is now the Cinderella of the oil industry and no longer the Orphan Annie, says T. F. McGarey of Cities Service Oil Company. Asphalt sales are catching up with motor oil sales, in dollar-volume. Annual sales of asphalt have reached $300,000,000; motor oil sales are $400,000,000. Percentage sales of asphalt are exceeding that of most products of the industry.

Chemical Process speeds oil field service in 5 states



Chemical Process' G-E radio system has grown right along with the company. Today it includes 25 base stations and 106 mobile units. Authorized General Electric service stations provide complete coverage in the field.

Overhead cut with General Electric two-way radio

Chemical Process Division of BJ Service, Inc. treats about 11,000 wells a year in five states. "Our rolling stock drives 500,000 miles or more a month and I don't see how we ever did without radio," says Mr. E. C. Burnett, Supt. of Communications.

One of the earliest users of General Electric two-way radio, Chemical Process knows how economical General Electric radio is to maintain. The new Progress Line with plug-in chassis saves them even more money through faster servicing. Either a transmitter or receiver can be replaced in five minutes right in the vehicle, using only a screwdriver. And with 50¢ worth of parts, you can even change from wide to narrow band reception (pioneered by General Electric).

Only General Electric gives you plug-in chassis, dependable communication-type tubes and controlled reluctance microphones for sharp voice transmission—*all at no extra cost.*

Look for your G-E communications consultant under "Radio Communications Equipment" in the Yellow Pages, or write: General Electric Company, Communication Products Dept. 3168, Syracuse, N. Y.

GENERAL ELECTRIC

Jersey Asks IPC Ownership

Standard Oil of New Jersey has indicated its intention of acquiring full ownership of International Petroleum Company, a large South American producing and distributing organization. Jersey Standard has registered 2,200,000 shares of its capital stock with the SEC to be offered in exchange for International Petroleum on basis of nine shares of its stocks for one of IPC. Jersey already owns 83 percent of IPC stock.

Bigger Oil Slice for Venezuela?

Venezuelan government may be making arrangements for increasing its share of revenue for oil, reports from that country indicate. Irritated with U. S. oil purchase cutbacks for her crude, Venezuela is looking for means to make up the loss. Some members and supporters of the new government have been agitating for 75/25 percent deals similar to those negotiated recently in Iran and Saudi Arabia.

Suntide Into Sunray

Merger of Suntide Refining Company into Sunray Mid-Continent Oil Company is expected about September 1, officials say. Suntide, through its subsidiary, Suntide Pipe Line Company, transports oil to the Suntide refinery. The company processes 65,000 bbl of crude daily at its Corpus Christi, Texas, refinery and markets its products through its deep-water terminal and pipeline and rail connections.

Washington Joins IOCC

The State of Washington has become the 29th member of the Interstate Oil Compact Commission. Governor Albert D. Rosellini signed the Compact agreement May 9. Until Washington found oil, it was an associate member. Granting full membership to Washington leaves only two associate members, states having prospects for oil or gas but not yet having production.

U.S. Wants 3 Miles—Texas, 10

Even if the federal government sets its continental boundary at 3 miles offshore, Texas still plans to ask for rights to explore to a 10-mile limit. The state's legal boundary is expected to be set in October with that of four other states bordering on the Gulf of Mexico. The U. S., which maintains its tidelands ownership beyond a 3-mile limit out to 10 miles, is also on record as stating it desires a federal boundary of 3 miles. At the Geneva Conference, now hoping to fix international offshore boundaries, U. S. is asking for a 3-mile limit; Russia is asking for a 12-mile limit.

More People, More Cars, More . . .

U. S. Census Bureau reports that the population has increased to 173,435,000 at the beginning of April. This was an increase of 225,000 over the March 1 estimate, and represents a 2,925,000 population rise since April, 1957.

DRY HOLES COST THE PETROLEUM INDUSTRY ABOUT A BILLION DOLLARS A YEAR... ALMOST 40¢ FOR EVERY BARREL OF OIL PRODUCED!

—A TIP from American Association of Petroleum Landmen

Super Tanker for Russia

Construction of a 40,000-ton super tanker has begun in Russia's Leningrad shipyards. The vessel, Russian publications say, will be capable of carrying 25,000 metric tons of liquid fuel of any type and will be able to make voyages of up to 10,500 miles without putting into port. This is in line with recently announced Russian intentions of penetrating foreign oil markets (i.e. Uruguay, other South American countries). Until now, Russia has had few tankers in which to export its crude and oil products.

Strike Stops Aurora Refinery

Some 345 employees have walked out of the Aurora Gasoline Company refinery in Detroit, Michigan, forcing shutdown of the refinery. Strike was called during a session with Federal mediators for the purpose of negotiating a new contract. Principal issues involve union demands for elimination of a no-strike pledge and removal of arbitration grievance settlement agreements, Aurora officials say. Aurora supplies products for eventual marketing in the Great Lakes area.

Changes Name

American Maracaibo Company has changed its name to Felmont Petroleum Corporation in an effort to better identify the firm's business and location. Company spokesmen indicate that it has only "insignificant interests in the Maracaibo Basin of Venezuela," principal holdings are in the Eastern Venezuelan Basin. The company's wholly-owned American subsidiary, Felmont Oil Corporation, is active in 10 states in the U. S. and in Canada.

Roads Not Slump Stopper

The federal and states governments' quick, concerted action on the new national highway building program is wonderful — but it won't become effective until the current recession is past, says Stanley C. Hope, president of Esso Standard. Hope, member of board of governors of National Highway Users Conference, indicated skepticism of the road program as a recession block — since impact would be felt in 1959 or later — after the nation is out of the recession, he predicted. Newly passed legislation earmarked $400,000,000 for immediate road program spending.

Net Savings at Peak

Securities and Exchange Commission reports that individuals, unincorporated businesses, trust funds and nonprofit groups increased their net saving $16.3 billion in 1957, compared with a $13.3 billion increase in 1956. Although the SEC made no 1958 trend forecasts, it stated that financial assets of this group amounted to $764 billion at the beginning of the year. Amount of increase in savings has not been surpassed since 1941, when net savings rose $41 billion.

Sets Safety Record

The U. S. oil industry has again broken its own safety record. API reports that both the frequency rate and severity rate again declined last year. Frequency rate of 7.05 represents a 3 percent reduction from 1956 and establishes a new low for the sixth consecutive year. Severity rate for 1957 was 712, a reduction of 17 percent from 1956. Frequency rate is determined by number of disabling injuries per million man hours worked; severity rate is number of days lost per million man hours worked.

Good Wells Make Good News

A Monthly Report of Successful Well Treatments

June, 1958

More and more operators are finding that acidizing can be their best well stimulation "buy." With Dowell's wide variety of acids and addition agents, you can select the service best suited to *your* well problem. Here are some interesting examples of recent Dowell acidizing treatments and their results:

- **St. Mary's Parish, South Louisiana.** (New Oil Well) This well was completed through 34 feet of perforations in the Miocene sand just below 13,800 feet. The well could not be swabbed in. Since permeability and porosity were high, operator suspected formation contamination from heavy mud. He ordered a 3000-gallon Mud Acid treatment. *After treatment, well came in without swabbing and is now producing 134 bopd which is top allowable for this field.*

- **Alberta, Canada.** (Old Oil Well) This well was completed through perforations into the D-2 formation between 5224 and 5260 feet. Production had declined, after a fracturing job, to six bopd. The operator decided to use a 2000-gallon Retarded Acid treatment followed by 2000 gallons of a mixture of crude oil and Freflo®. The well was shut in for 12 hours and then put on production. *After three months, production is still 48 bopd.*

- **Hansford County, Texas Panhandle.** (New Oil Well) This well was completed in the Atoka lime through perforations from 7086 feet to 7116 feet. There was no test before stimulation. Treatment was in two stages, using a total of 7000 gallons Dowell regular acid with both surface-tension-reducing and demulsifying agents added. *Two and a half months after treatment, well is making 395 bopd.*

- **Hardin County, Texas Gulf Coast.** (Old Gas Well) Production from this well, drilled in the Cook Mountain formation, had declined to one mmcfd with 40 bbls. distillate. Tubing pressure had dropped to 1200 psi. A workover failed to help the well. Dowell recommended a mud removal treatment using 1000 gallons Super Mud Acid, followed by a wash with 1000 gallons regular acid. A special silicate control agent was added to both acids. Following treatment the well cleaned up fast. *Production increased to 2.6 mmcfd with 124 bbls. distillate, and tubing pressure rose to 2600 psi.*

When you specify Dowell for acidizing you get the benefit of more years of experience in oil well acidizing than you can get from any other service company. For service, call any of the 165 Dowell service points and offices. In Canada, contact Dowell of Canada, Ltd.; in Venezuela, contact United Oilwell Service. Or write Dowell, Tulsa 1, Oklahoma.

Services for the oil industry

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A SERVICE DIVISION OF THE DOW CHEMICAL COMPANY

The Most Advanced Power Package You Can Buy...

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When it comes to filling the power requirements for the Petroleum industry — whether it be for pumping, drilling, electrical generating or other specialized applications — the Mercedes-Benz is ready to provide you with quick, dependable power at the flick of your finger. Unusually long engine life and continuous operation under extreme climatic conditions are made possible by their exclusive, ultra-modern design. Indeed, the Mercedes-Benz is the most advanced power package available today!

MODEL MB 837 Aa
565 h.p. at 2200 r.p.m.

Other Mercedes-Benz diesels available in 12 and 20 cylinders, Turbo and Supercharged, up to 3000 h.p.

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SPECIAL TOOLS AND EQUIPMENT
DUMP BAILER SERVICES
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FORMATION TESTING
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ACIDIZING SERVICES
FORMATION FRACTURING
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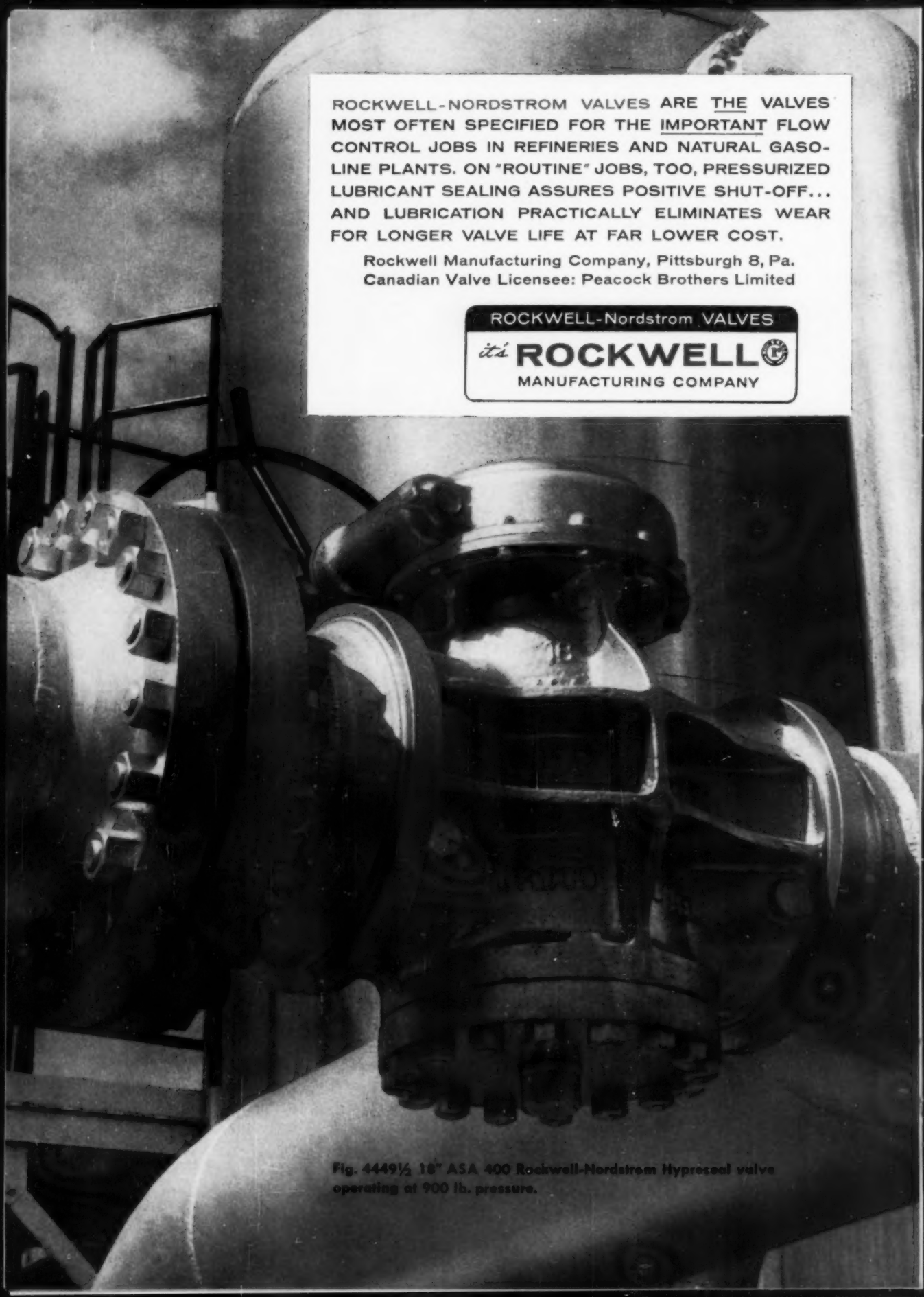
PANORAMA of POTENTIAL
Through its own lens of experience and research, each Halliburton service brings a view of technological advance for better well completion. Halliburton's integrated services, each bringing to the others the vision and perspective of its own, produce a panorama of potential that seeks to effect full realization of every well's potential.

HALLIBURTON OIL WELL CEMENTING COMPANY
DUNCAN, OKLAHOMA

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



ROCKWELL-NORDSTROM VALVES ARE THE VALVES MOST OFTEN SPECIFIED FOR THE IMPORTANT FLOW CONTROL JOBS IN REFINERIES AND NATURAL GASOLINE PLANTS. ON "ROUTINE" JOBS, TOO, PRESSURIZED LUBRICANT SEALING ASSURES POSITIVE SHUT-OFF... AND LUBRICATION PRACTICALLY ELIMINATES WEAR FOR LONGER VALVE LIFE AT FAR LOWER COST.

Rockwell Manufacturing Company, Pittsburgh 8, Pa.
Canadian Valve Licensee: Peacock Brothers Limited

ROCKWELL-Nordstrom VALVES

it's ROCKWELL MANUFACTURING COMPANY

Fig. 4449½ 18" ASA 400 Rockwell-Nordstrom Hypreseal valve operating at 900 lb. pressure.

You're Money Ahead to

MEASURE PIPE PROTECTION WITH A CALENDAR

How should pipe protection be measured? By first cost? By ease of application? By appearance?

With all the claims made for protective tapes, too often the most important consideration is overlooked—the simple point of how long and how well it will protect the pipe.

Since 1941, when TAPECOAT originated coal tar coating in tape form, this protection has proved to be the best that money can buy for combatting corrosion underground or under water. Lines in service, TAPECOATED as far back as 17 years ago, show no signs of deterioration—a record of uninterrupted performance *no other type of tape can match*. Think what this means in terms of preventive maintenance and elimination of replacement costs!

After all, hot-applied coal tar has proven over the years to be the most dependable and enduring protection. And because TAPECOAT is a hot-applied coal tar coating in tape form, it offers the same lasting protection.

A TAPECOAT sales and service engineer is available at all times to assist you on any corrosion problem and on the various applications of TAPECOAT.

Write for complete details today.

PROVED IN SERVICE

...Underground or Under Water on

Pipe	**Tanks**
Pipe Joints	**Tie Rods**
Service Connections	**Conduit**
Mechanical Couplings	**Cables**
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TAPECOAT comes in rolls of 2", 3", 4", 6", 18" and 24" widths—sized to the job. Available also in asphalt. Where primer is desired, specify TC Primecoat, the compatible coal tar primer.

TAPECOAT®
A PROTECTIVE COATING

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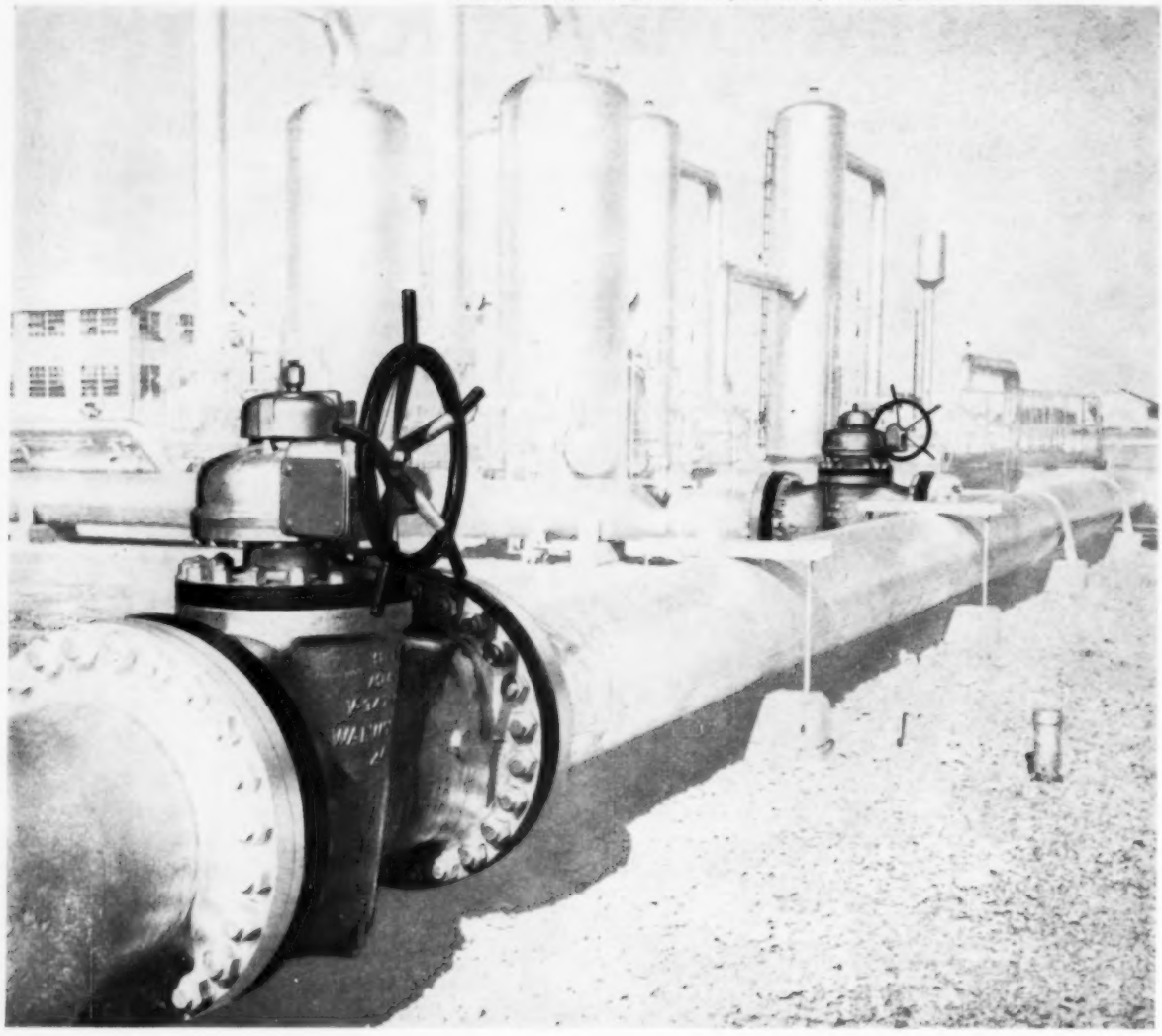
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Shown here are Walworth 24" Ball Bearing Gear Operated Type Lubricated Plug Valves on inlet to scrubbers in a gas booster station. Walworth Lubricated Plug Valves are available in sizes from ½" to 30" for pressures up to 5,000 psi and for vacuum service.



FOR ABSOLUTE DEPENDABILITY... WALWORTH LUBRICATED PLUG VALVES

There are sound reasons for depending upon Walworth Lubricated Plug Valves in exacting pipeline service. They afford absolute shutoff when closed. They provide quick, easy operation whenever needed—a quarter turn of the plug opens or closes the valve. They are free from costly deterioration in periods of non-use.

Superior engineering and precision construction mark every lubricated plug valve that bears the Walworth name.

Other Walworth products used by the oil and gas industries are gate, globe, angle, and check valves; and pipe fittings—in a wide range of materials, types, and sizes.

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Compressibility Factor Charts

For Natural Gas Calculations

Carl Gatlin
The University of Tulsa

Notice: This replaces and corrects Sheet 1 which was published August 1957. Please file accordingly.

The gas law applied to the behavior of natural gases is most commonly expressed as:

(1) $pV = znRT$

where:

p = pressure, absolute
V = volume
n = number of mols
z = compressibility (also called deviation) factor to account for the difference between actual and ideal gas volumes.
R = gas constant
T = absolute temperature

The value of R is dependent on the system of units used as listed in Table 1.

Table 1. Values of the Gas Constant, R, for Some Commonly Used Units of p, V, and T.

p	V	T	R
lb per sq in.	cu ft	°Rankine	10.73
lb per sq ft	cu ft	°Rankine	1545
atmospheres	cu ft	°Rankine	0.7302

Determination of "z." Theory and background of compressibility factor determinations is completely covered in various texts. [1,2] Briefly, the values of "z" for natural gas mixtures have been experimentally correlated as functions of pressure, temperature, and gas gravity.

Compressibility factor for natural gases are functions of pressure, temperature, and composition. The latter variable, composition, must be known in order to compute the molal average critical (called pseudo critical) pressure and temperature. In many cases the chemical analysis is not available and pseudo critical properties must be estimated from the gas gravity, which is normally known. Several correlations relating gas gravity to pseudo critical pressure and temperature have been published. [3,4,5]

Curves published here have been developed from the gas gravity vs pseudo critical property data of Brown, et al., [4] and the compressibility factor vs reduced property data of Standing and Katz.[3] Similar curves based on a different correlation have been presented by Buthod.[6]

In these curves z may be obtained directly for a given gravity, pressure and temperature. Values at intermediate gravities may be easily interpolated. Curves are provided for condensate and miscellaneous casinghead gases. Differences in the z values of these two systems become significant for all gravities above 0.65 and for 0.65 gravity at temperatures below 200 F. Where the source of the gas is unknown, values of z from the miscellaneous (dashed lines) gas curves should be used.

Example Problems

1. A cylindrical tank contains miscellaneous 0.80 gravity natural gas at 2500 psia and 100 F. The volume of the tank is 10 cu ft. How many lb of gas are in the tank?
   (Note: Molecular weight of air is 29 = number of mols.)
   Solution:
   $$n = \frac{pV}{zRT} = \frac{(2500)\,(10)}{(0.67)\,(10.7)\,(560)} = 6.2 \text{ lb-mols}$$
   Weight = 6.2 x 0.80 x 29 = 144 lb
2. 1000 std cu ft are released from the tank. The final tank temperature is 60 F. What is the final tank pressure?
   (Note: At standard conditions, one mol equals 379 cu ft).

Solution:

$$\text{Mols remaining} = 6.2 - \frac{1000}{379} = 3.6 \text{ mols}$$

$p = \frac{znRT}{V}$ but z = function of p, therefore the solution requires trial and error.

$$\frac{p}{z} = \frac{(3.6)\,(10.7)\,(520)}{10} = 2000$$

Assume (1) p = 1500, then z = 0.581, $\frac{p}{z}$ = 2580 (high)

(2) p = 1300, then z = 0.681, $\frac{p}{z}$ = 2100 (high)

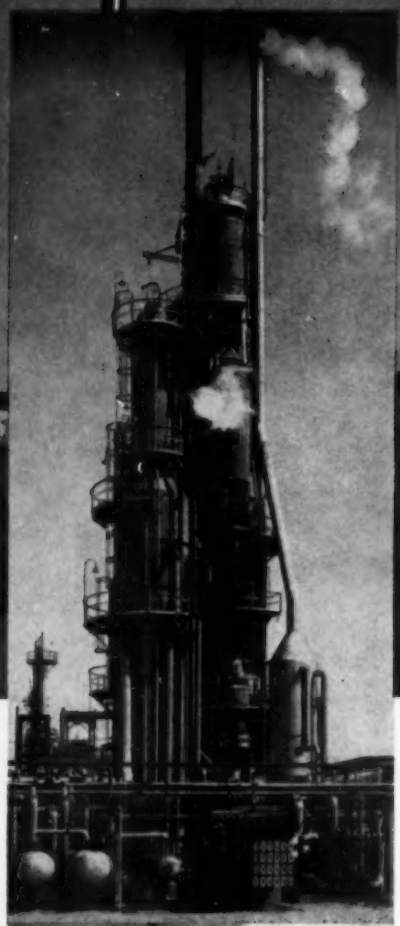
(3) p = 1250, then z = 0.627, $\frac{p}{z}$ = 1995 (close enough)

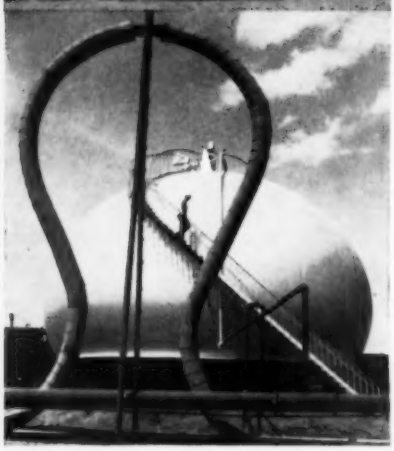
∴ final p = 1250 psia

(Values of z are obtained from 0.80 gravity chart.)

References

1. G. G. Brown, D. L. Katz, G. G. Oberfell, R. C. Alden, Natural Gasoline and the Volatile Hydrocarbons, section one, Mid-West Printing Company, Copyrighted by Authors.
2. M. B. Standing, Oil Field Hydrocarbon Systems, Reinhold Publishing Corporation, 1952.
3. M. B. Standing, D. L. Katz, "Density of Natural Gases," *Trans.* AIME. Vol. 146, (1942).
4. G. G. Brown, et. al., op. cit., p. 44.
5. M. B. Standing, op. cit., p. 26.
6. Paul Buthod, "Compressibility Factors and Specific Heats of Natural Gases," the *Oil and Gas Jour.*, September 8 and 28, 1949.





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• Above, right: 10-ft. diam. by 38-ft. reactor; 5-ft. stripper and 16-ft. diam. by 49-ft. regenerator were fabricated and erected by CB&I for APCO at Cyril, Oklahoma.

• Top, above: Components for this 4,600-bpd, UOP Catalytic Cracking unit at APCO Arkansas City Refinery were fabricated and erected by CB&I in 1951.

• Above: Hortonspheroid® at Cyril, Oklahoma APCO refinery.

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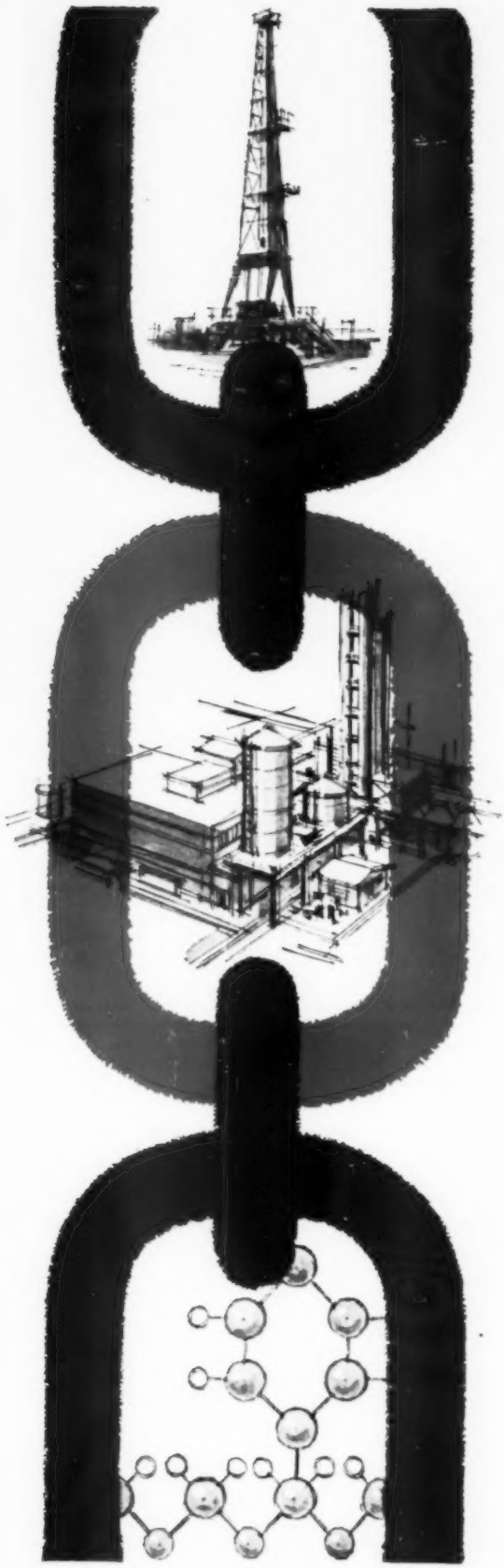

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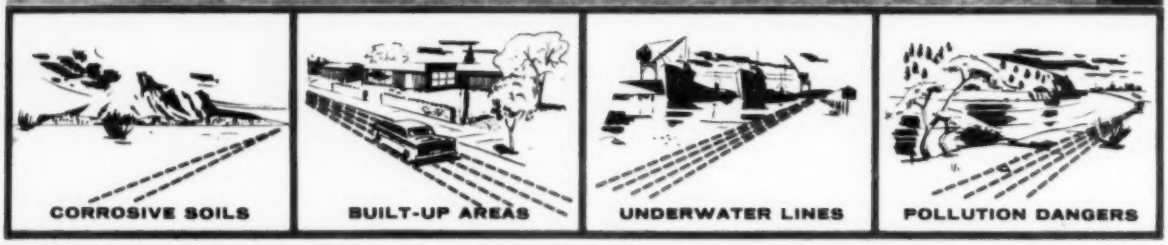

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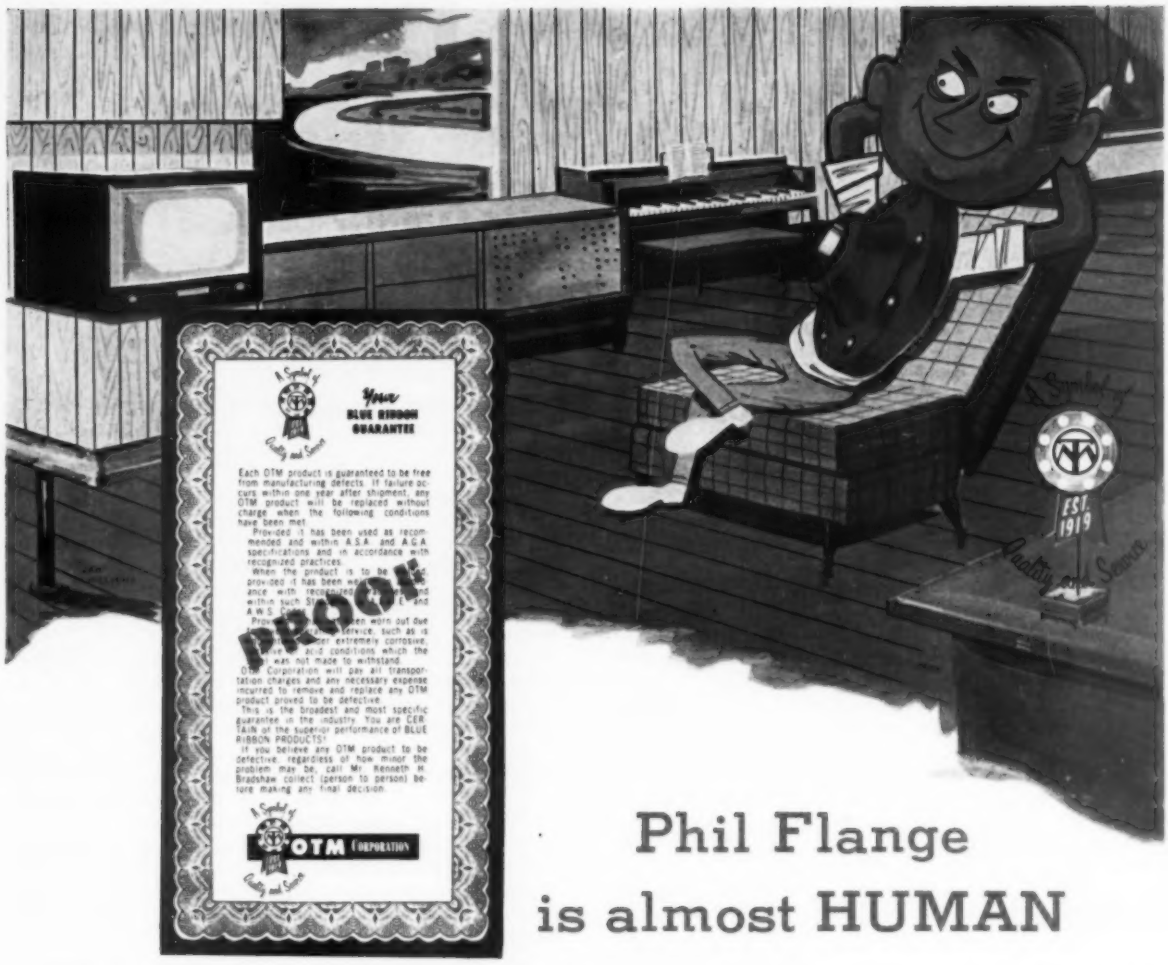
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1. Canadian View
2. European View
3. Venezuelan View
4. Administration View
5. TIPRO's View
6. Oil Producer's View

IF YOU ARE EASILY SWAYED by arguments you'd have been wavering this way and that in the great debate on imports at TIPRO's 12th annual meeting May 11-14 in San Antonio.

Texas Independent Producers and Royalty Owners Association members listened to opinions from many viewpoints. We've collected six salient sides in this printed forum. A three-man panel moderated by Harold Vance set the stage for the imports symposium.

J. A. Cogan, vice president and director of Imperial Oil, Ltd., presented his view of imports and exports between Canada and the United States.

Dr. Eduardo A. Acosta H., Minister Counselor of Petroleum Affairs with Venezuela Embassy, Washington, explained his country's trade relations with U.S.A.

B. N. Darbyshire, European consultant, pleaded for a two-level price structure. He felt a $1.00 or $1.25 a barrel tariff would give Europe and many backward countries cheaper oil.

Another facet of the many sided problem was turned by Captain Carson at a luncheon address. As the program stated: "At the height of TIPRO's battle for Congressional action to limit oil imports, it is appropriate to hear Captain Matthew V. Carson, Jr., director of the U. S. Interior Department's Office of Oil and Gas and administrator of the President's voluntary import-limitation program."

To round out the symposium, we include Jerome J. O'Brien's remarks on imports in his president's report and W. E. Turner's rebuttal to Carson's statistics.

THIS DOESN'T PRETEND to be all sides. It isn't even comprehensive. Some interesting and debatable arguments are advanced.

TIPRO as an organization supports passage of the Ikard bill. It is joined by most producing organizations. This legislation now before Congress would maintain imports of foreign crude and production at the 1954 relationship of 16.6 percent of domestic production of crude oil. The President would allocate quotas by source countries. Under the bill importers would competitively bid for the right to import crude oil and products.

Only one impromptu speaker advanced the idea that the Ikard bill could possibly be defeated and it might be wise to explore the possibility of a straight tariff.

Darbyshire apparently found wholehearted audience approval. Asked if he believed in a two-level price structure, he agreed it would be a good thing.

There is no need to conserve oil, he said, as atomic energy will meet most energy needs by the end of this century. In Darbyshire's view no power stations fueled by anything except nuclear power would be built in Europe after 1965; all large ships constructed after the next 10 to 15 years will be powered by atomic energy. Now Europe and low standard countries need cheap energy that Middle East oil can provide.

Cogan stressed that pipeline imports should be differentiated from others. They should come first in any U. S. oil import policy because of the security aspects of imports by pipeline.

A question to Acosta brought out the fact that Venezuela's production is 2,500,000 bbl a day. Consumption is about 110,000 bbl a day, leaving the large balance for export.

In answer to a question on Canadian oil production per day per well, Cogan said recent allocations were 30 bbl. Darbyshire estimated Middle East wells produced 7000 bbl and Acosta judged Venezuelan wells at 200 bbl output.

Darbyshire was asked if tax on oil products was very high in Europe and he said it was — running some 30 cents a gallon on gasoline. He felt countries needed enlightening on this score, especially in regard to taxes on such products as diesel oil.

The comments quoted above followed statements we publish on the following pages. These do not convey the consensus of the meeting itself — that without Congressional action the industry, so far as the independent producers is concerned, is dead.

ONE MEMBER ASKED Cogan: "Do you believe the U. S. oil industry should be destroyed in order that the U. S. manufacturing industry can sell to Canada and Venezuela?"

Cogan, of course, did not believe present conditions had the elements of destruction but, he replied, his answer to the question would be "No."

Despite the emphasis on unified support of the Ikard bill, there was a minority satisfied with the Voluntary Imports program. They spoke quietly and doubtless they were those who had not been hurt — at least not much — by the Texas 8-day allowable.

The most important item of all was the fact that on the TIPRO platform you could hear arguments on almost every side. No matter where you stood on imports you heard opposition — which has a salutory effect. It is to the credit of TIPRO and its officers that they invite those with whom they do not agree. The plan provides a fast course on any problem.

1. Canadian View

Exempt Pipeline Imports

J. A. COGAN GIVES FOUR REASONS WHY HE BELIEVES OIL FROM CANADA IS AN EXCEPTION TO THAT FROM OTHER COUNTRIES AND SHOULD BE TREATED ON A SEPARATE BASIS.

I MUST ADMIT to a degree of diffidence in appearing at a time when an unfortunate combination of circumstances has reduced the Texas allowable to 8 days. However, I do find some justification for feeling almost at home when it is realized that in Alberta (sometimes termed the Texas of Canada) allowables this month are also 8 days average for all proratable fields, falling to less than 5 days average for those major fields making up some 65 percent of the efficient productive capacity of the province.

On this basis the total actual production for the entire province this month will be but one-third of its total maximum efficient rate of production. The existence of such a situation in the case of the United States' closest ally and neighbor is, of course, no consolation and no basis for failing to appreciate the full gravity of your problem here.

However, I'm sure you wouldn't want me to be less than frank in trying to present my interpretation of the "feel" of the situation from a Canadian viewpoint.

Canada, as you know, is a trading nation, and is therefore vitally concerned with international trade in the broadest sense. This general statement, furthermore, is equally valid when narrowed down to oil as the subject matter for my discussion today.

As most Canadians understand it, (and you can certainly correct me if I'm wrong), limitations have been imposed on U. S. imports of crude oil primarily for the dual purpose of protecting both the national security and the health of a strategically vital industry. These, of course, are principles with which it is difficult to take exception. Starting from this point of view, there are several points related to Canadian oil which would seem worth enumerating.

Canadian Oil Strategic

No. 1. Dealing first with the compelling national security problem, it would appear that the concern with regard to vulnerability of imported oil should not apply to Canadian oil, particularly when imported by pipeline, since under the concept of continental defense this oil is strategically as secure as domestic United States production.

The Canadian production is in fact the best located to serve both in peace and war many parts of the northern and western United States. For example, the recent Suez experience indicated the unusually high value from a logistics standpoint of the Canadian crude oil available on the West Coast. Since that time additional pipeline capacity has been added to further assure the security of West Coast supplies.

Competition Same As in U. S.

No. 2. Canadian oil is not likely to have sharply adverse effects on the economic health of the United States oil industry. This is because conditions under which crude oil is sought and produced are so similar in Canada to those in the United States. The opportunity is open to any operator, large or small, to compete in the Canadian petroleum development, and not only major companies, but scores of independents (many from the United States) have taken advantage of this opportunity.

A recent survey, for example, indicated some 220 companies active in crude oil production in Western Canada. From a geologic standpoint the Western Canada sedimentary basin occupies a generally similar setting to much of the United States Mid-Continent basin.

It is also particularly important to note that as in the United States, the authorities in Canada have adopted conservation methods including prorationing of production to market demand. Under these circumstances Canadian oil is priced on a basis similar to that in the United States and does not represent a serious threat to the economic stability of United States production.

Best Customer of U. S.

No. 3. Arguments against import limitations on a trade and economic basis, are, of course, generally applicable. This is, however, a matter of degree and Canada has a particular position with respect to trade with the United States that is unique.

U. S. exports to Canada have been running at an annual

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J. A. COGAN

J. A. COGAN, a vice president and director of Imperial Oil, Ltd., Toronto, Canada, is a graduate of Colorado College (BA in chemistry, 1930) and Massachusetts Institute of Technology (MS in science, 1932).

In 1932 he joined Standard Oil Company of Louisiana, an affiliate of Standard Oil Company (New Jersey), as a process engineer in Baton Rouge. He moved to New York two years later to become a member of the Jersey company's coordination manufacturing group, subsequently incorporated in the coordination and economics department.

During the Second World War Cogan was on leave to serve with the Petroleum Administration for War. Returning to Jersey, he became assistant head of the coordination and economics department. In 1947 he was appointed head of the same department.

In 1954 Cogan joined Imperial Oil as assistant manager of the manufacturing department and became responsible for long-term planning of manufacturing operations. In January 1956 he became a director of the company, and the following year he was appointed a vice president.

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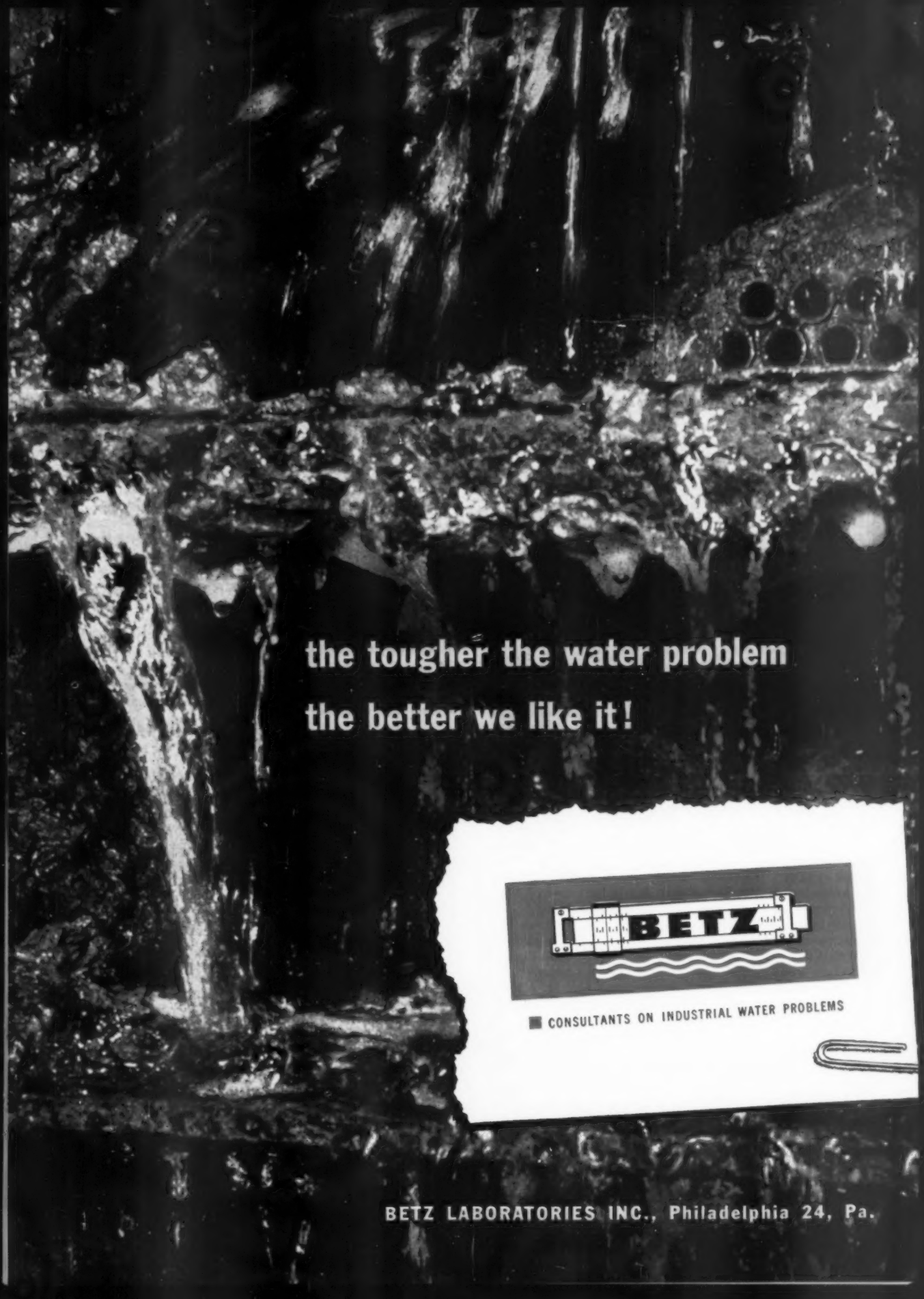
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2. European View

Mideast Oil Should Be Cheaper

B. N. DARBYSHIRE SUPPORTS HIGH OIL TARIFF ON THE THEORY THAT PRICES IN REST OF WORLD WOULD FALL AND BRING LOW COST ENERGY TO COUNTRIES THAT NEED IT TO IMPROVE LIVING STANDARDS.

AT THIS TIME you are faced with the crucial problem of protecting your industry, now more gravely menaced than ever before by imports from dirt cheap sources of production. I am an economist by training, an internationalist in outlook, a firm believer in the merits of competitive production, pricing and international free trade, and if that is not enough for you I will say that I am also convinced of the imperative need for lower crude oil prices in the Eastern Hemisphere. Then we could supply the essential cheap energy without which living standards cannot be raised in both the developed and the underdeveloped countries and large sections of the world lifted thereby from poverty and saved from political extremism.

I believe these most sincerely. How then can you expect me to support your request to your Federal Administration and to Congress for effective tariff protection?

Support High U. S. Tariff

Curious though it may seem at first thought, I do believe most wholeheartedly in the necessity of a high American tariff on petroleum imports today.

If this were a free world full of peaceful nations, I would definitely be opposed to your quota or tariff demands. But unhappily it is an extremely dangerous world and Middle East prices are not formed by competitive selling between the companies operating there.

Because Middle East Is Unstable

The enormous reserves of oil which we now know do exist in the Middle East (approximately 75 percent of the total reserves of the free world) are extraordinarily vulnerable to military attack and to political changes in those unstable countries. We cannot afford to be dependent on them in consequence. The Suez fiasco should have proved that to all but the weakest and most confused minds.

This is my main reason for supporting your demands for a minimum of $1 a barrel tariff on imported oil though personally I think that it might well be another 25 cents higher especially when freights are as low as they are today.

It is essential that you should maintain a healthy, active, self sufficient domestic industry with reserves readily accessible for export so long as the world we live in remains menaced by the threat of further international strife. You need it for your own security, and we in Europe need your reserve capacity for our security as was proved so conclusively only 15 months ago.

Because Middle East Prices Would Fall

In order to justify the high level of Middle East crude oil prices the companies operating there have utilized the argument that these prices are established by economic forces involving competition with Texas oil when both are landed on the U. S. Coast. The difference between Texas prices on the Texas fields and Middle East prices on the Middle East fields being a result of overcoming the necessarily greater cost of transporting crude all the way from the Middle East to the U. S. East Coast and surmounting the present small import tariff.

Now this argument — poor though it is, for Middle East prices do not in fact fluctuate with fluctuations in ocean tanker freight rates — is the only economic argument of any validity at all in the attempted justification of non-competitive pricing of Middle East oil between producers out there.*

As a result it follows that Middle East producers would have to lower their posted Middle East prices by an amount equal to any U. S. tariff increase!

This would be the healthiest and happiest thing that could happen in the world petroleum industry. Middle East oil prices have been far too high for far too long. Yet it has not been possible to lower them without destroying the U. S. high cost industry until you insulate yourself with some form of tariff (as in the Ikard bill for instance). If you will do that,

*EDITOR'S NOTE: Mr. Darbyshire seems to advocate area pricing here, which is not always practical in the petroleum industry. It is what we object to in the utility-type pricing of natural gas sales. If a profit had to be made on each area then a large amount of production would be priced out of the market.

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B. N. DARBYSHIRE

BERNARD N. DARBYSHIRE, economist, petroleum consultant and authority on Middle East oil, is a native of Northern England, educated at the Universities of Dublin and Geneva and the famous Graduate Institute of International Studies, Geneva. He specialized in economics, political science and international law.

He joined Shell Oil Company as an economist in London, 1946, where he gained experience in major company operations. His desire for a more active and independent life led him to take over management of a refinery construction and engineering company in 1948. During the next few years he traveled extensively in Europe and Africa managing the company and negotiating political concessions for clients in the oil business.

In 1952 he became an independent consultant, advising mainly on Europe and Middle East oil problems. For the past three years he has been occupied primarily with geological work and exploration in North Africa, Europe, and the Near East, and serves as advisor to the Swiss MIGROL Company. He has engaged in consulting or refinery construction in 35 countries.

3. Venezuelan View

Trade Agreements are the Answer

DR. EDUARDO A. ACOSTA H. POINTS OUT U. S. EXPORTS TO VENEZUELA ROSE 55% IN 1957 OVER 1956; PETROLEUM EXPORTS FROM HIS COUNTRY TO U. S. INCREASED ONLY 11.5%.

PETROLEUM IS and has been for years a matter of mutual interest to both the United States and Venezuela. In the many years of Venezuelan trade with the United States, petroleum and petroleum products have played a major role, and have helped in the development of the economies of both countries.

We for our part have been sending oil to the United States, thus supplying markets in this country in a supplementary form. In exchange we have been taking larger and larger amounts of U.S. goods to the extent that in 1957 the trade balance was definitely in favor of the United States and by a sizeable amount.

Venezuelan exports to the United States in the above year were of the magnitude of $897 million. U. S. exports to Venezuela during the same period totaled approximately $1,050 million in goods alone.

To this an additional estimated amount of $500 million in what is called invisibles or intangibles such as payment for services rendered to different branches of the business fields of the United States, is to be added. This brings the total sum spent by Venezuela in the United States to about $1,500 million.

Trade Balance Favors U.S.

Exports of petroleum and petroleum products from Venezuela to the United States have increased by 11.5 percent from 1956 to 1957, but on the other hand exports from the United States to Venezuela were 55 percent higher in 1957.

And it must be borne in mind that the data are not exactly comparable. The percentage increase in U. S. imports from Venezuela was due to the repercussions of Suez. Venezuelan oil helped avert a shortage on the U. S. East Coast due to the interruption of supplies from other foreign sources. It is feasible to say that the 1958 trade balance could be even more favorable to the United States.

It should be emphasized at this point that U. S. exports to Venezuela cover many items that come from most of the States of the Union. It is apparent from these figures and from those of previous years that imports from Venezuela to the United States have had a counterpart from the United States to Venezuela. Trading between the two countries has been straightforward and fair. Trade, I would say, is good for both of us, the advantages have been mutual and have resulted in a strengthening of the economic bonds between our two nations.

However, although trading is strictly a business proposition I should mention at this point that Venezuela's attitude has not been purely that of a good merchant. Behind the serious faces of our hard boiled negotiators there has been the flicker and twinkle of the flame of friendship, and I believe that Venezuela in this respect has proved to be a friend of the United States in times of bonanza and in times of emergency.

To this end it is to be remembered a gesture of Venezuela in 1950, at a time when oil imports into the United States were considered on the high side. This gesture was in the form of a communication sent by the then Minister of Development to top government officials of the State of Texas. This cablegram in brief stated that Venezuela would subscribe to a gentleman's agreement designed to relieve the tension that could exist in the American oil industry on account of oil imports.

There is yet another angle to be analyzed. The importance of the oil industry of Venezuela is understood when considered in its proper perspective, that is, from a continental point of view. It is unquestionable, as it has been pointed out by oil experts, that the petroleum axis of the world has its poles in the Eastern Hemisphere, covering the Middle East and adjacent areas of Rumania and Southern Russia, and in

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DR. EDUARDO A. ACOSTA H.

DR. EDUARDO A. ACOSTA H., Minister Counselor of Petroleum Affairs with Venezuelan Embassy, Washington, is a civil and petroleum engineer with degrees from the University of Caracas and the University of Texas. A native of Caracas, he began his career in petroleum with Creole Petroleum Corporation in 1940.

Dr. Acosta has held numerous positions in the Venezuelan Government, as well as being active in the oil industry in his country. He has been government petroleum inspector and assistant chief, Division of Exploration, Refining and Transportation, Ministry of Development, 1944-46. He was assistant chief, Conservation Department, Ministry of Development and Ministry of Mines and Hydrocarbons, 1946-55.

He left this post and became petroleum consultant for the Central Bank of Venezuela after which he organized his own petroleum consultant service. He was president of INGECAR (civil engineering activities), 1956-58.

Dr. Acosta is associated with several private consulting firms and a member of the Board of Directors of ATI (Association Tecnica Industrial). He has acted as consultant for Superior Oil Company, Continental Oil Company, Paria Operations, Pan-Venezuelan Oil Company, Phillips Petroleum Company, and others.

Dr. Acosta assumed his present post early this year, succeeding Carlos Perez de la Cova, who is now the head of Venezuela's Ministry of Mines and Hydrocarbons.

4. Administration View

Voluntary Plan Is Working

CAPTAIN MATTHEW V. CARSON, JR., ANSWERS THREE CHIEF CRITICISMS OF VOLUNTARY PROGRAM AND EXPLAINS REASONS FOR SOLVING CURRENT PROBLEMS WITHOUT RESORTING TO RIGID CONTROLS.

MANY THINGS have been said about the Voluntary Oil Imports program, and I would like to discuss these with you:

1. **The program has "broken down."**
2. **Crude oil imports are mounting constantly.**
3. **Restrictions are inadequate.**

To most people who have been impressed by these criticisms, it usually follows that mandatory controls on crude oil imports which restrict them to a certain level, usually the 1954 ratio of imports to domestic production, will solve the current troubles of the petroleum industry.

I think that all three of these criticisms are false, and the so-called solution which follows is equally false.

Has the Program "Broken Down"?

This criticism is ambiguous because it is difficult to define. For the moment, let's assume it means the program has been a failure because the Government has not gained complete compliance by all importing companies. It could also mean that the program is a failure because imports in any given month — or even week — are over the recommended level, but we will discuss this aspect later.

The Federal Government has issued 58 separate import allocations, and to my best knowledge, there has been no deliberate attempt to ignore these individual allocations, except in three cases. From this, I think that I can say we have gained 95 percent compliance in the past nine months. Now, as you have undoubtedly read, one company which had previously not been in compliance is now and probably will remain so in the future. This means we now have 97 percent compliance.

Viewed in this light, I think only a rigid and unreasonable perfectionist would say the program has "broken down."

Are Imports Mounting?

From July through March, crude oil imports averaged 801,100 bbl daily in Districts I through IV. This means that crude oil imports have been reduced by 168,900 bbl daily, or 17.4 percent, below the levels originally scheduled by the importing companies prior to the Voluntary Oil Import program. And, I think it is fair to say that, without the program, imports might have exceeded the originally scheduled levels.

This nine-months average is only 2.3 percent above the level recommended by the Special Committee to Investigate Crude Oil Imports and approved by the President. It means, that in nine months, we have accomplished 97.7 percent of the goal which originally was scheduled to be met over a period of a year.

Crude oil imports from September, the first month in which the program became fully effective, through March, averaged 765,600 bbl daily, almost 2 percent below the recommended level.

Imports of crude oil, as originally scheduled, represented 16 percent of domestic production. From July through March, we cut that ratio to 13 percent. From September until the present, the ratio dropped to 12.5 percent — one-half of one percent above the overall goal.

Again, I think only the most rigid perfectionist would say the program is a failure because in nine months, we have been 97.7 percent effective rather than 100 percent.

Is the Level Set Too High?

As a starting point, the people who say the level set by the Special Committee is too high usually say we should revert to the 1954 ratio of imports to domestic production. This is the *magic* level at which our troubles will disappear — or, at least, we are told they will disappear.

The first question, of course, is where did this determination about the 1954 ratio originate? Who said that imports should be held to that precise level?

In February 1955, the President approved the report of the Committee on Energy Supplies and Resources Policy. In that report, the committee stated that crude oil imports, in its opinion, would endanger the national security if they "significantly" exceeded the 1954 ratio. Please notice the committee used the word "significantly." They did not specifically say that *all* imports over the 1954 ratio would impair national security.

Now, the rigid perfectionist again might say that we have failed because imports from July through March were 13

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CAPTAIN CARSON

CAPTAIN MATTHEW V. CARSON, JR., USN, Director of Office of Oil and Gas, U. S. Department of the Interior, and administrator of the President's voluntary oil imports control program, is a former Hearne, Texas, attorney on active service with the Navy since 1940.

Before becoming administrator of the import program in July 1957, Carson, a graduate of the University of Texas, was legal officer of the Third Naval District in New York City. He also served with the Joint United States Military Group in Spain, and from 1951 through 1953 he was associated with the Office of Naval Petroleum Reserves — first as counsel, then as director. He has also served with the U. S. Sixth Fleet in the Mediterranean and with the Munitions Board.

During World War II Captain Carson commanded four destroyer escorts and took part in four major campaigns in the South Pacific.

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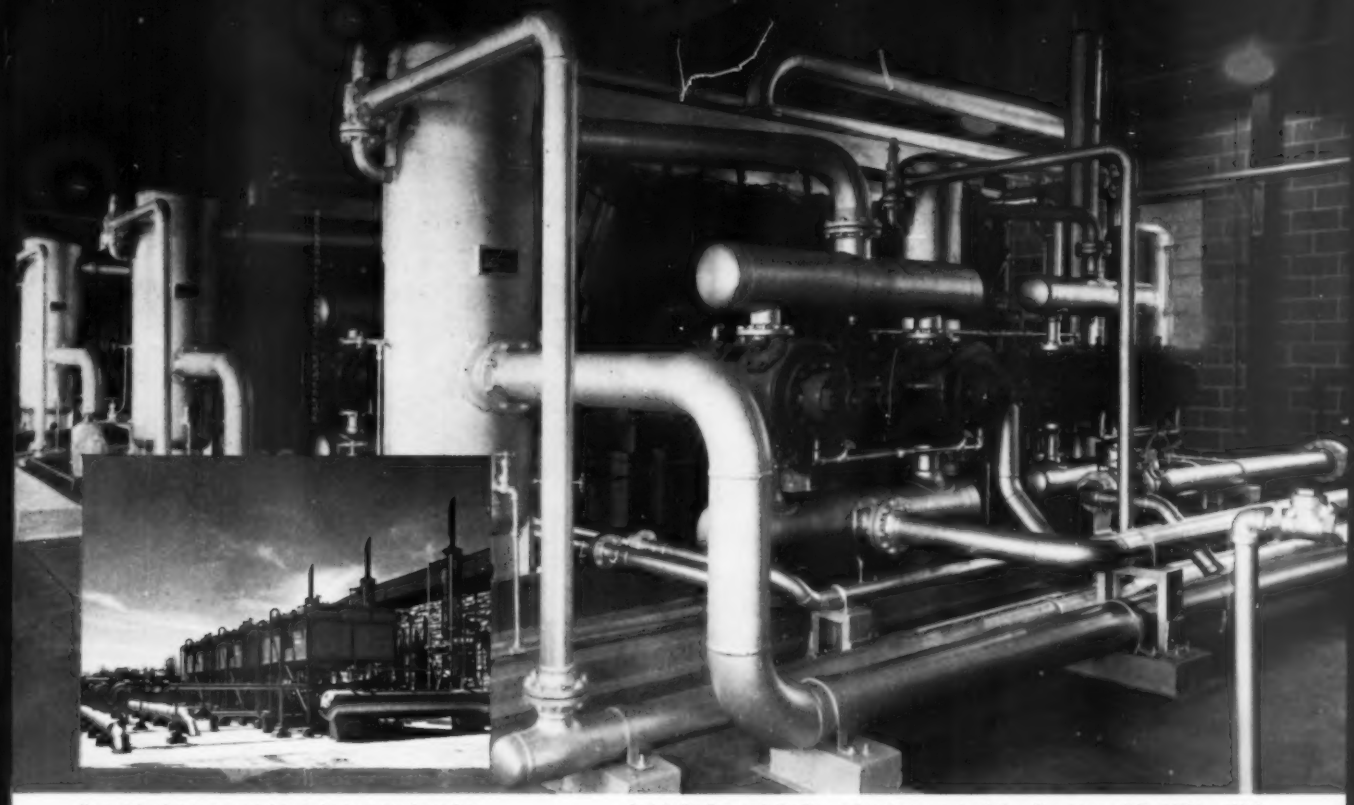

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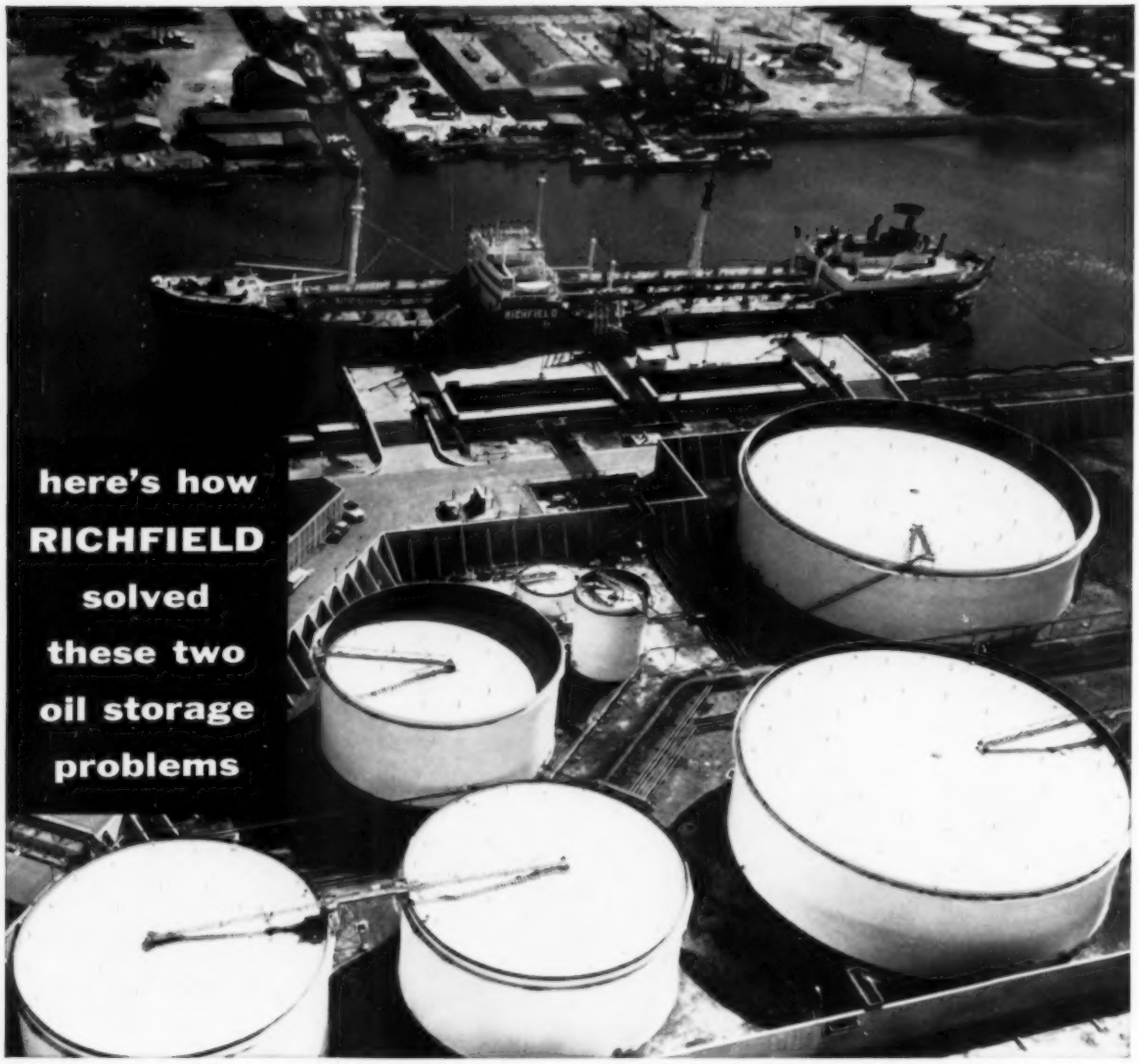

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5. TIPRO's View

Voluntary Plan Not on Target

W. E. TURNER BELIEVES OBJECTIVES OF CABINET COMMITTEE HAVE BEEN SIDE-TRACKED AND THAT "PROPER BALANCE" OF IMPORTS AND DOMESTIC PRODUCTION CANNOT BE ATTAINED.

The Cabinet committee report made it clear that "if we are to have enough oil to meet our national security needs, there must be a limitation on imports that will insure a proper balance between imports and domestic production." In discussing what constituted a "proper balance," the committee indicated that domestic production, exploration, and reserves were the guiding factor.

The report listed the following as consequences of a failure to maintain "proper balance":

1. "Oil imports will flow into this country in ever-mounting quantities, entirely disproportionate to the quantities needed to supplement domestic production."
2. "There will be a resultant discouragement of and decrease in domestic production."
3. "There will be a marked decline in domestic exploration and development."

A "proper balance" between imports and domestic production, then, would presumably prevent the developments listed above, and if the current voluntary program is a "success," there should be no adverse effects on production, exploration, or reserves.

Here are the facts of the situation by the committee's own criteria:

● Since the program went into effect, imports have averaged about 1,551,400 bbl a day. This compares with an average of 1,436,000 bbl daily in 1956 and only 1,051,000 bbl daily in yardstick year 1954. Thus, imports have continued "to flow into this country in ever-mounting quantities."

● Since 1953, total demand has increased only about 17 percent, while imports have increased 47.5 percent and domestic production only 11 percent. In yardstick year 1954, crude imports into Districts I-IV amounted to 11.3 percent of domestic production; so far in 1958 they have averaged 14 percent of domestic production. In March 1958 total imports amounted to about 25 percent of domestic production as compared to 16.6 percent in 1954.

● In July 1957, the month the program went into effect, the U. S. produced 7,089,000 bbl of crude oil daily. In March 1958, we produced only about 6,134,100 bbl daily — a decrease of 955,300 bbl a day. There has been, then, "a resultant discouragement of and a decrease in domestic production."

● Reliable estimates are that drilling will drop about 18 percent in 1958; the number of active drilling rigs operating in Texas is already some 39 percent below the level of a year ago; and in 1957, for the first time in 25 years — with the exception of the war year 1943 when a steel shortage developed — the U. S. used more oil than it proved up in new reserves. The excess of production over new reserves was about 349 million bbl.

Thus the voluntary program falls vastly short of success whether measured by Congressional intent in providing the law or by the administration declaration in its July 1957 report.

W. E. TURNER, executive vice president of TIPRO, gave this short rebuttal to some data contained in Captain Carson's speech.

NEVILLE G. PENROSE, Fort Worth oil producer and chairman of TIPRO's Imports committee, reported these resolutions, which were unanimously passed by the members: (1) to support the Ikard amendment to the Trade Agreements bill: (2) to proclaim the failure of the Voluntary Plan; (3) to acknowledge the sincere and outstanding efforts of the administrator of the Voluntary Program, Captain Carson; (4) to commend certain state and national officials for outstanding work on the imports problem.

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percent of domestic production and since September have been 12.5 percent.

Now, who made this policy determination concerning the 1954 ratio? The members of the 1955 committee were the Secretaries of Defense, State, Treasury, Labor, Commerce, and Interior.

Last July, another committee recommended the level should be 12 percent. Who served on this committee? The Secretaries of Defense, State, Treasury, Labor, Commerce, and Interior.

We must also look into this matter a little further. To what extent was the 1954 policy determination changed in 1957? The precise ratio of crude oil imports to domestic production in 1954 was 11.3 percent in Districts I through IV. The 1957 ratio was set at 12 percent — a difference of seven-tenths of one percent.

It would be revealing, especially to those who believe firmly that the 1954 ratio would solve their problems — it would be revealing to translate the difference between the 1954 ratio, had it been strictly adhered to, versus what has actually happened since the program has been operating.

Now, let's take a look at what is involved in the differences between the 1954 ratio of 11.3 percent of crude oil imports to domestic production in District I through IV and the actual level of imports that prevailed in 1957.

In 1957, total crude oil production in Districts I through IV averaged 6,244,000 bbl and imports averaged 737,000 bbl daily. Applying the precise 1954 ratio of 11.3 percent

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6. Oil Producer's View

Ikard Bill Will Be Effective

JEROME J. O'BRIEN REVIEWS RESULTS OF VOLUNTARY PROGRAM, URGES SUPPORT OF IKARD BILL, WHICH HOLDS IMPORTS OF BOTH CRUDE AND PRODUCTS TO 16.6 PERCENT.

DURING THE PAST YEAR our greatest preoccupation has been with oil imports. Since this month last year, allowable producing days have been slashed in half, while imports of oil and products have risen from 19.2 percent of domestic production to more than 25 percent.

The President's voluntary program for controlling imports has served, along with decreased allowables and the oil industry depression, to point up the need for a legislative remedy.

We have never contended that the Cabinet Committee program has not been helpful. It undoubtedly has reduced imports of crude oil far below the levels they would have reached without this Administrative restraint. The program's administrator, Captain Carson, has earned our respect by executing the plan with impartiality.

Program Not on Target

But to say that the program has been effective in helping the domestic oil industry to remain capable of meeting defense requirements is like saying the doctor improved the patient's condition before he died. Whatever may be said about the program's having come close to its target, the fact remains that it has not hit that target.

It is inadequate in concept. It not only has failed to carry out the intent of Congress in setting up the executive powers which made the program possible — that is, the intention to restrict imports with a 16.6 percent relationship to domestic production — but it has failed even to achieve the more modest goals prescribed by the 1957 Cabinet committee.

The new policy of denying military contracts to noncomplying companies seems to be having some effect. But even with full compliance by all companies, imports will continue to grow much faster than domestic production, as they have done even under the program. Crude imports have risen from 938,000 bbl a day to an average of 995,000 — an increase from 12.6 percent to 16.2 percent of domestic production — in one short year.

Support Duty on Imports

Even while working hopefully for positive action by the Administration — and again I say we are grateful for as much as has been done — TIPRO has advocated a legislatively-imposed duty or excise tax as the most effective, most equitable solution, as well as the most advantageous to importing companies and oil-producing foreign nations.

Because we have pursued that goal — and I will say unequivocally that TIPRO has led the field in pursuing the duty as an avenue of relief — we now have what could well be the instrument of our deliverance. We have high hope for the bill introduced by Congressman Frank Ikard of Wichita Falls, Texas, which would hold imports of oil and products within the 1954 ratio of 16.6 percent, and would collect a duty on every barrel by granting import licenses to companies on a competitive bid basis. The Ikard bill is a proposed amendment to the Trade Agreements Extension Act and is titled the Mineral Resources Security Act of 1958.

The Ikard bill has the support of independent producers throughout the country, other defense-vital industries, and many members of Congress from a large number of states. It is the best and most practical proposal TIPRO has yet taken into consideration. In fact, the import-license feature was advanced by TIPRO in the course of searching for the most workable solution to the imports problem.

Imports Hampered Pipeline Project

One of the projects to which we have devoted our best efforts is the removal of obstacles to a crude oil pipeline linking oil-surplus Texas with oil-deficient California. Among our activities was the presentation of testimony before the Imports Administrator and ODM Counsel, showing how exemption of the West Coast from imports restriction helped prevent the construction of this line and effectively defeated the objective of the voluntary program.

Adding materially to the strength of our position have been several studies or reports, such as the Interstate Oil Compact Commission's report on the effect of imports on conservation and a Justice Department report issued last September which analyzed and acknowledged the antitrust implications of the present situation.

JEROME J. O'BRIEN

JEROME J. O'BRIEN, ninth TIPRO president, is vice president and manager of Monterey Oil Company's Mid-Continent operations. He has an excellent technical background, a geology degree from UCLA in 1932, and a petroleum engineering degree in 1934 from University of Southern California.

He worked with a number of oil companies in many capacities before he joined George McCarthy in 1943 to organize Shamrock Drilling Company of Los Angeles.

He became manager, in 1948, of the Texas and Oklahoma operations of Jergins Oil Company and its successor companies in San Antonio. In the past nine years he has been executive vice president of Jergins and president of Monterey Exploration before being appointed to his present post.

He does so many jobs for the industry, it would be hard to name them all. He has worked in TIPRO, IPAA, is a director of API and of Mid-Continent Oil and Gas Association, and is a working member of AAPG and other professional organizations.

1. Canadian View

BEGINS ON PAGE E-3

rate of approximately $4 billion, making Canada the United States largest single customer by a wide margin, since no other single country has been importing even $1 billion worth of commodities from the United States.

As the United States has in turn been importing but $3 billion worth of commodities from Canada, the net adverse balance of trade for Canada with the United States has been running at about $1 billon per year. This adverse balance alone is, as previously indicated, greater than the total gross exports from the United States to any other country.

Obviously limitations on crude oil imports into the United States from Canada must in the long run result in lesser shipments to Canada from the United States than would otherwise be possible on the part of the large number of United States exporters of all types who value Canada as a customer.

From a Canadian viewpoint it is rather difficult to follow why, with all the millions of U. S. taxpayers' money going to promote international trade and understanding, Canada as the best friend of the United States is not permitted to earn its own way and set the stage for even greater expansion of U. S. exports.

Canada Net Oil Importer

No. 4. As a matter of equity Canadian oil's position as a comparative newcomer, would appear to merit some recognition. Canadian oil has not had time to obtain, through gradual growth, a base level comparable with those of other principal sources of imports into the United States.

Additionally it appears important to recognize that Canada as a whole is not a net exporter of petroleum. It thus contributes a net market to other world sources of supply which would appear to justify special consideration for Canadian exports and a sympathetic understanding on the part of such exporting countries.

It would, of course, be possible for Canada to obtain a self-sufficient position through exclusion of imports into the distant eastern Canadian markets traditionally served by imported supplies. This, however, would be economically wasteful and would represent further restriction in world freedom of trade.

THESE SEVERAL POINTS just discussed represent much of the case for exemption of Canadian crude oil from United States import limitations. Now this does not mean an open end invitation or opportunity to add to imports into the United States. In fact, it need not result in any increase at all in the total volume of imports. Exemption could for example be applied in some such manner as:

1. Receive nominations first from those wishing to import oil by pipeline from countries of origin or from countries which are not net exporters of petroleum. (This would not appear to conflict with the Most Favored Nation principle.)

2. Subtract these volumes from the total desired level of imports to determine the remaining quotas available.

We believe that some such procedure would be in the interests of all concerned. The advantage from a Canadian standpoint is, of course, obvious. The advantage to other countries which are sources of U. S. imports, while less obvious, is nonetheless real, since some potential gradual addition to the use of Canadian oil in the United States should be much preferred by such countries to the very real alternative of the major loss of the eastern Canadian market.

Finally, from a U. S. standpoint, for a given level of imports a maximum contribution to national security would be obtained with a minimum impact on the economic health of the vital oil industry.

2. European View

BEGINS ON PAGE E-6

prices of oil reaching the rest of the world will fall to more reasonable levels and consumption will grow faster in the parts of the world that desperately need low-cost energy.

There is no other economic formula that the companies could adopt to justify the maintenance of the present level of Middle East crude oil prices. They have known for a long time that if the American tariff is increased their Persian Gulf prices must come down, otherwise they would stand proved participators in a grand cartel.

No wonder that they desperately resist the imposition of an American tariff! Not just because they are worried about the profits on their cheaply produced imports into America; that is a minor matter, but they are desperately fearing to lose the unnecessarily large profits made on supplying Middle East oil to the rest of the free world at prices which have a fantastic relationship to cost of production and no possible justification except on the basis of being competitive with Texas oil at the U. S. East Coast.

No wonder also that they do not quarrel too fiercely with the plan for the voluntary import quotas, for with this scheme the Eisenhower Administration enables them to maintain the Middle East price levels.

American legislators who oppose a high tariff on petroleum imports would do well to consider this aspect of the matter. It is no use giving extensive lip service to the idea of free trade unless you have a competitive price system back of it, and lacking this, those who do so are either defending special interests or so ignorant of international economic affairs that they should not be in responsible positions today.

Because Free Trade Is Stymied

The Eisenhower Administration has had many opportunities to stop the Middle East oil price racket which is almost certainly the greatest commercial scandal in the history of the world to date.

They cannot plead ignorance: They inherited from President Truman an excellent Federal Trade Commission Report on the International Petroleum Cartel, and a pending suit against the major Middle East oil companies for violation of the anti-trust acts, a criminal suit which when they came to office they were in positively indecent haste to abandon.

In the five years that have passed since then these American companies have continued to milk the free world and you cannot therefore be very surprised if people overseas take a somewhat cynical view of your Government in consequence.

The matter was again pointed up in 1955 by the publication of the United Nations Economic Commission for Europe's Report on "The Price of Oil in Western Europe." Your Government had every opportunity both at the Geneva meeting which considered this report and by administrative and judicial measures to initiate action which would have corrected this situation without harming the domestic industry.

It took none, although the report found that in 1952 in Saudi Aradia 300 million barrels were produced and sold at a price of $1.75 a barrel and a net profit of $1.40 a barrel was being earned, and also that the Middle East prices could not be regarded "as resulting from the free play of competitive forces."

Ultimately this so called cheap Middle East oil may cost more, because these people seem never satisfied with their share of the profits. Certainly they will demand more if we ever lose alternative sources. But in the meantime, I can see no good reason why Europeans should pay artificial prices just because America won't protect her own industry by a higher tariff.

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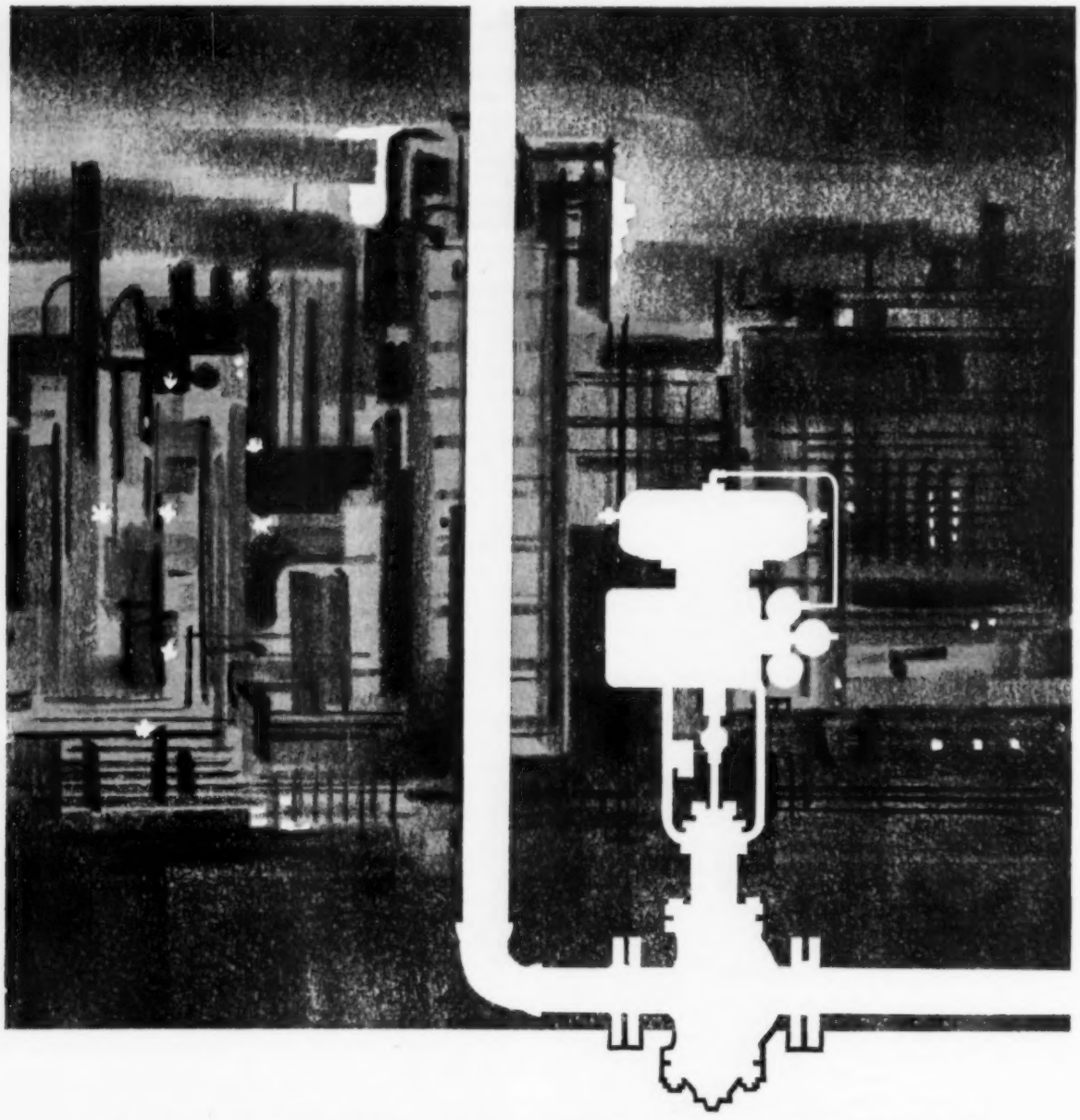

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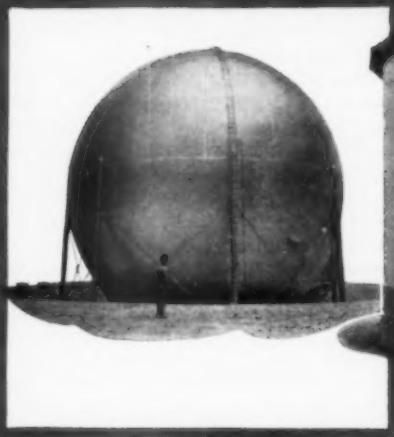

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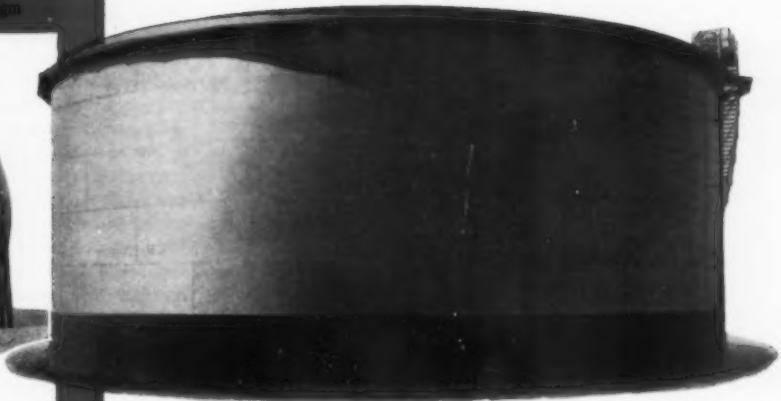

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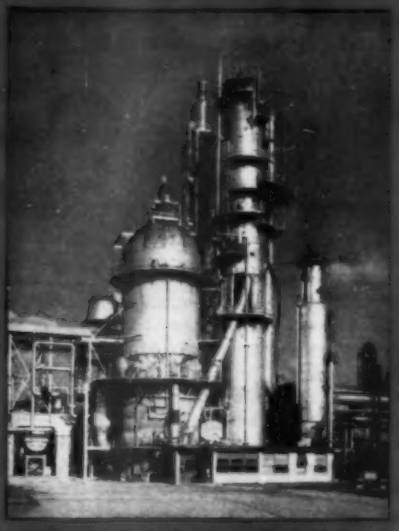

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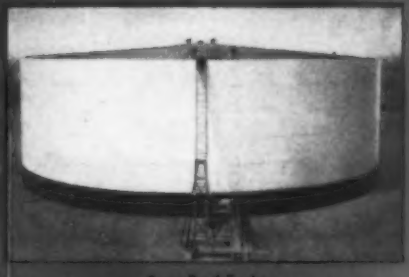

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Let us now have a closer look at these Middle East crude oil profits. How much are they? Well, in 1947 Mr. James Andrew Moffett, former board chairman of Cal-Tex, testified before a Senate Investigating committee that lifting costs in Saudi Arabia were 3 cents per barrel, and costs delivered to the refinery there were not more than 13 cents including overhead. At the same inquiry, Mr. James Terry Duce, vice president of Arabian American Oil Company admitted that operating expenses were 7.96 cents per barrel and total expenses including 21.99 cents per barrel of royalty were 33.10 cents per barrel, and Mr. H. M. Herron, chairman of the board of Bahrein Petroleum and of California Texas Company, Ltd., stated that the cost of producing oil in Bahrein was approximately 25 cents per barrel including 15 cents per barrel of royalty.

This means that on a Middle East production now running at over 1,400,000,000 bbl per year, profits are being made by the companies operating in the Middle East of the order of $1050 million this year and the royalty owning countries are taking the same rake off. In the case of Saudi Arabia it amounts to around $260 million for Aramco and $260 million for Saud this year. Please understand that I am not opposed to high profits, as such, when they are economically justified.

Now gentleman, these are sizeable figures, and when there is a considerable doubt about the fairness of the price structure on the basis of which these profits are being accumulated it is pertinent to look also at what is being done with the money. The oil companies for the most part are using these massive profits made in the crude oil end of the business to finance their activities in the fields of tanker construction, refinery expansion and expanded market facilities.

The net result is that for many years now in the Eastern Hemisphere the major companies who control Middle East production have been absorbing independents in the fields of refining and marketing until only a steadily dwindling number of quasi-dependents representing unimportant shares of the markets still remain.

Case Study

Here is one case of a company with whose development I have been associated during the last 3½ years. MIGROL Company in Switzerland entered the distribution business in October 1954 starting with six back street gasoline stations two each in Geneva, Basel, and Zurich.

The object was to break the cartelised Swiss gasoline market and sell only at a reasonable profit. MIGROL sold 83/85 octane gasoline at 10 cents per gallon below the existing cartelised market prices. By efficient buying, transportation and organization MIGROL made a profit and has steadily expanded its activities until today it has almost 100 stations covering the whole of Switzerland.

The major companies have been forced to reduce their prices by 9 cents per gallon throughout Switzerland and because they are inefficiently organized with high overheads most of them are now running at a loss on their marketing organizations. MIGROL continues to make a profit and to expand.

In an endeavor to stop this, American companies marketing there have frequently tried to undersell MIGROL and other independents by deliberately reducing prices to completely uneconomic levels at their nearest service stations.

Fortunately all the Swiss public are not as stupid as to fail to realize that if the independents were put out of business gasoline prices would soon be back at 60 centimes a litre where they were when the market was successfully cartelised by the majors up to 1953, and so MIGROL has survived and today sells at 47 centimes per litre.

Key American Ally in Middle East

I could further illustrate how impossible it has been to obtain independent refinery capacity in Northern Europe as a result of actions taken by the major companies. These then are just some of the difficulties that have faced European independents in recent years as a result of excessive profit making in th Middle East.

On the other hand, what of the governments in the Middle East who collect these easily earned royalties? How do they spend their substance? In the case of Iraq, Kuwait and Persia, national economic development programs are in being and royalties are in large part well spent or invested. This is particularly the case in Iraq where very great progress is being made, and also in Kuwait which cannot currently find enough outlets for the capital available for economic development.

However, in one country where American influence and American capital is one hundred percent concerned we find a totally different story. The King of Saudi Arabia has been an absolute monarch taking his royalties and spending them in the most decadent fashion that imagination could consider. Reports indicate that the desert is littered with Cadillacs and Royal palaces.

He has bedevilled Middle East politics with bribery and attempted bribery on an enormous scale, and has corrupted where he could for his own ends. There has been virtually no attempt to initiate economic developments benefiting the people, it is reported that the Royal Palace in Riyadh consumes four times as much electricity as the capital town!

It may be news to some of you that Saudi Arabia is a slave-owning state, and the best informed estimates put the number of slaves today at somewhere between 600,000 and one million. The conditions in which some of these slaves are kept is as bad as anything since the days of the Roman Empire. I have reliable testimony vouched for by the Anti-Slavery Society in London of inhuman practices too unpleasant to detail to you. Yet this country is the key American ally in Middle East.

American legislators who still oppose a high crude oil tariff on the grounds that it would damage international trade might also do well to reflect on how vast a sum in scarce dollar currency is sucked from struggling countries by American oil companies selling Middle East oil at these excessive prices.

Much of the aid which your country has so generously given to the world in the years since the war has been leached back in this way. If their dollar resources were not being used up for this purpose many countries would have much larger amounts to invest in development projects and in American manufactured goods.

Your Government, I regret to say, has signally failed to do anything to stop this wholly iniquitous and harmful exploitation of the oil have-not countries by American companies. Your Congress can now do so and at the same time protect your domestic industry and your national security by instituting a high tariff.

My purpose has been to assure you from a different vantage point that your demands for tariff protection at this time are not only merited by your needs, but they are, by a fortunate fact of economics, in the best interests of those hundreds of millions of your fellow men who do not enjoy your living standards and whose only real hope of economic betterment is through cheaper energy rapidly harnessed in the service of mankind.

We know that sufficient energy is readily available in the vast oil reserves of the Middle East, it should be the purpose and the responsibility of oil men to supply it bountifully and cheaply pending the arrival of nuclear power. You can help to achieve this end by obtaining your tariff protection.

You are fortunate indeed, in that seldom can self interest so happily coincide, in a matter of this sort, to serve the interests of so many millions in the world at large.

3. Venezuelan View

BEGINS ON PAGE E-7

the Western Hemisphere in the Gulf of Mexico-Caribbean-Canada area.

This emphasizes the strategic value of oil sources found in the American Continent because these are not subject to international political pressure and disputes that would render unavailable other world sources of petroleum in times of emergency.

When called upon, the role played by the Venezuelan oil industry, in particular in moments of world crisis such as during World War II, the Korean situation, and the Suez bottle-neck, has been prompt and responsive in alleviating tremendous pressures brought upon our friends of the Western Hemisphere and in Europe.

For Venezuela to maintain its position as a supplier of oil in the American Continent, in times of bonanza and also to have a quickly responsive reserve in times of emergency, it must keep its oil industry wealthy, strong and friendly, and this cannot be done if every phase of the industry is not kept going and progressing on a precision like basis. This requires timely drilling of wells to increase oil reserves and sufficient oil production to provide for a convenient economic platform to support the development of the country in all of its economic aspects.

Much has been said year after year regarding the importation of petroleum and petroleum products into the United States. Domestic producers in the United States have had a tendency to blame oil imports for production set-backs. This as a generalization seems to be unrealistic and could even be dangerous. Continental unity calls for unity in many fields; political and economic principles and the like.

From a continental point of view, oil found in the American Continent is domestic oil, and if we are to live in accordance with the continental principles of men like Washington and Bolivar, and today's concept of the Monroe doctrine, we must strive to build and work together so that the countries involved will continue to develop and prosper.

Trade Agreements Needed

The proper way to handle these matters is through adequate and well balanced trade agreements. I do not know whether friendship derives from fair trading or if fair trading is the result of friendship. But I do know that in either case friendship can always be preserved and trading can always be maintained on an equitable basis.

The tendency to blame oil imports and to present them as a scapegoat to rescue lost economic advantages is not fair because there are other factors involved. These factors are also very important and each one should be viewed from its proper angle.

The utilization of natural gas and natural gas liquids has increased tremendously in late years and these fuels have been making in-roads upon oil markets. Thus, oil consumption on an energy basis has leveled off and has even tapered off in late years. As a contrast, natural gas and natural gas liquids consumption has been climbing steadily on a steep angle.

Another factor that has concurred to stiffen production set-backs at this time is the current business recession that has slowed down many fields of industrial and commercial activities. However, this factor is of a temporary nature; therefore, it is correct to assume that once it is removed from the business picture it will cease to act adversely on oil activities.

In brief, of the factors which now affect production of petroleum in the United States one is of a temporary nature and one could be classified as of a permanent character. The solution to the problem posed by the former comes through modern and well-known economic practices. The way to handle oil imports in a business-like manner cannot be other than through international trade agreements, because trading is a two-way street and no harm can derive from it if carried out on a fair and equitable basis.

Substitution of oil gas fuels by gas fuels is a growing tendency in the world. It has proved to be very strong in the United States. It has begun to grow and cut into European markets. Let us hope that energy consumption requirements world-wide will continue to expand in order to permit the efficient and rational utilization of all of the fuel resources of the earth.

Before closing it would be proper to touch on a last but not least important point. Oil production set-backs in the United States have not caused as much unemployment as would result from the slowing down of other industrial and commercial activities. However, in Venezuela production cutbacks do have a more profound effect as the entire economy is affected by the oil industry. We consider our oil industry a national industry which finds its counterpart in every oil producing country of the world.

4. Administration View

BEGINS ON PAGE E-8

to 1957 domestic production would mean a difference of 31,000 bbl daily in Districts 1-IV under actual imports.

Are Restrictions Adequate?

The Voluntary Program was never charged with the responsibility to control product imports. Under the law enacted by Congress, the Director of the Office of Defense Mobilization is charged with the responsibility of certifying to the President when, in the director's opinion, any commodity — any commodity — not just petroleum — is being imported into this country in such quantity as to threaten to impair the national security.

When this certification is made, again under the law, the President shall cause an investigation to be made and if he finds that such is the case he may take such action as he deems necessary. The Director of the Office of Defense Mobilization made a review of the petroleum product import situation just a little over two months ago, and as a result of that review he found that he could not certify to the President that petroleum products were being imported in such quantities as to threaten to impair the *national* security.

Those are the facts, and here are some more about products. Did you know that 86 percent plus of product imports are residual heating oils? Did you know that production of residual oil in Districts I-IV was less last year than it was in 1943? Do you know why?

Because the yield from a barrel of crude oil has decreased unto residual constitutes only 12 percent of the yield. More modern refining techniques have resulted in higher yields of the lighter and more valuable end of the barrel. Last year, the demand for residual increased by some 10 percent over 1956, but the production of residual decreased in Districts I-IV by some four percent.

Residual oil, as you know, is used principally on the East Coast as a fuel source for large industrial and institutional installations. We simply don't make enough residual in Districts I-IV to meet the demand.

I have attempted to give you facts which are often overlooked or willfully ignored by the proponents of other systems or plans. There is an increasing number of people in this country that have adopted the theory that government should take care of us from the cradle to the grave. There are proponents of "big government" who believe that the people are just too dumb to be trusted to solving their own problems. I do not subscribe to those theories and I do not believe that you do. ★ ★ ★

Banff School Expands

Sponsored by four Canadian Universities, advanced management courses at Banff now given in fall and winter for six weeks to take care of growing enrollment

Administration building at Banff School.

Donald Cameron

STARTED as an experiment in 1952 by the University of Alberta, The Banff School of Advanced Management has, in six years, grown to one of the important management training centers in Canada. Beginning with an enrollment of 24 executives in 1952, the school has grown to 35 in 1953, 68 in 1954, 69 in 1955, 77 in 1956, and 92 in 1957.

The original class was mainly from Alberta, then 1957 registration came from six of the Canadian provinces and from some of the states of the United States. Although started by the University of Alberta, the school is now sponsored as a cooperative venture of the universities of Alberta, British Columbia, Saskatchewan, and Manitoba.

The school is housed in the facilities of the Banff School of Fine Arts and Centre for Continuing Education at Banff, Alberta. Living and classroom conditions are ideal, duration of the courses six weeks, cost of room, board and tuition is $800.

Among the executives attending the six week sessions are to be found representatives of most Canadian industries and businesses. The 1957 class, for example, included 18 men from the petroleum and petrochemical industries, 9 from the lumber and forest industries, 4 from manufacturing, 4 from merchandising, 7 from the cooperatives in grain handling and wholesaling, 3 from banking, 2 from newspapers, 3 from mining, 7 from utilities, 9 from wholesale distribution, 6 from metal and fabricating, 4 from insurance companies, 2 from the armed services, 2 from professional groups, and 13 miscellaneous.

Subject matter of the program presented by the combination of the lecture, seminar, and case methods of study includes: Canadian economic scene, business policy, administration practices, human relations, labor relations, personnel administration, financial controls, financing enterprise, production management, marketing, government and business.

Careful attention is paid to maintaining close contact between instructor and student by restricting classes to a maximum of 35 students. In other words, from now on the enrollment will be limited to a maximum of 70 students, and these will be organized in two classes to whom the lecturers will present their material in successive class periods. In addition, the student body is further divided into a number of study groups of not more than seven or eight students. These groups meet for two hours every evening, five evenings a week, for the purpose of discussing and analyzing practical business cases and problems which have been assigned to them in class.

Emphasis is placed on keeping the course as practical as possible consistent with providing the maximum amount of background information to the proper discussion of the topics. The course also is designed to develop a wider horizon and a new sense of the increasingly important dual role that the executive must play in his community as businessman and citizen.

The school is staffed by a highly qualified group of 12 university instructors and businessmen brought together from all over Canada and the United States but the core of the teaching staff necessary to maintain continuity in the program is provided by the Schools of Commerce of the four participating universities.

These men have discharged their responsibilities so well that in each of the last three years a substantial number of students have had to have their applications for admission deferred for one year or more. In spite of careful screening of candidates and deferments the demand has continued to grow to such an extent that starting in the fall of 1957 two schools per year were organized.

The fall school is scheduled from the first week in November to the middle of December, and the winter school from the first Monday in February to the middle of March. A special quota is held open for students from American industry in order to bring in a wider range of business experience, laws and customs.

In general it can be said that the school is aimed at middle management and upward. One prerequisite is that a man must have been in business for at least 10 years before he will be admitted. He must be 28 years of age and the upper ceiling, while not rigidly enforced, is set tentatively at 48. The great demand for this type of executive training is at once a reflection of Canada's thriving economy and a portent of a new and closer relationship between adult education and the business community. ★ ★ ★

Mr. Cameron is executive director of The Banff School of Advanced Management.

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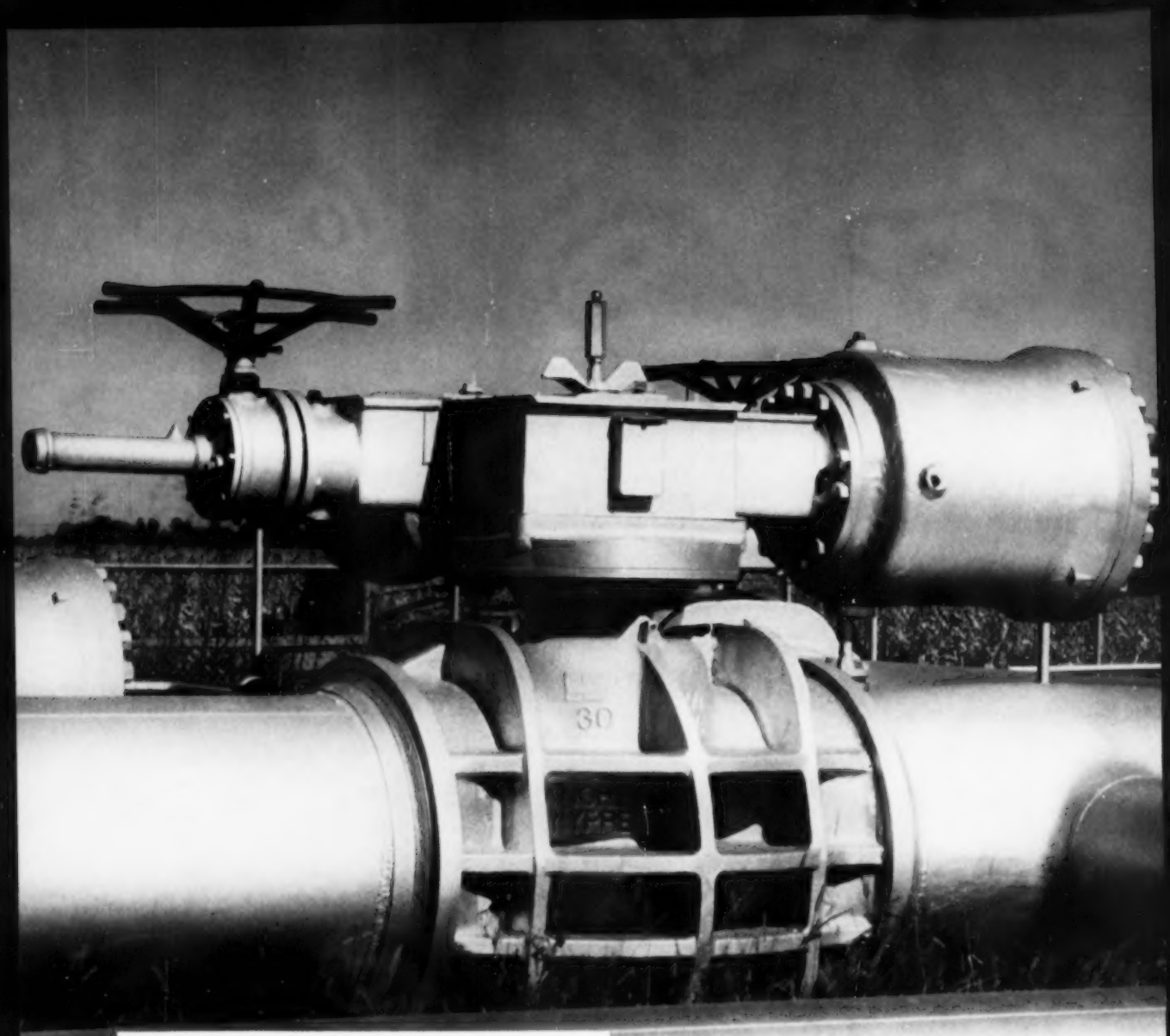

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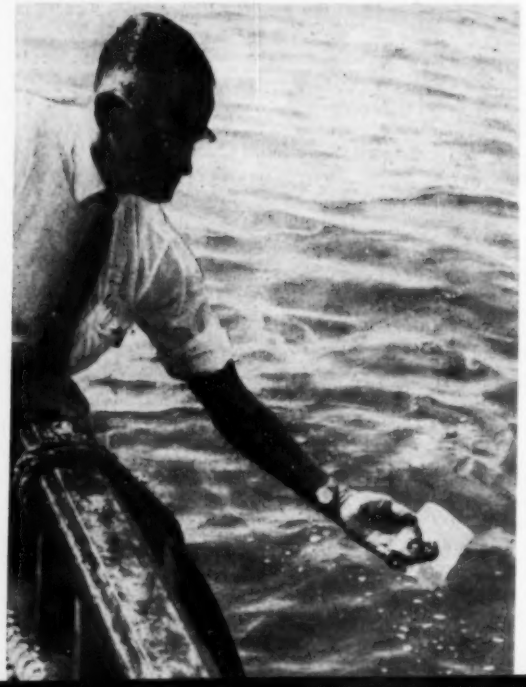
Public relations is not an easy job as the petroleum industry knows so well . . . Lots of PR work has to be done over and over again . . . here's a report on one repeater handled by an expert

El Segundo Has a Problem

Waste Disposal Foreman Bob Allen makes periodical collecting trips to compare leaks with oil being run by refinery.



Globs of oil are skimmed from surface of ocean off El Segundo by Dave Jones, refinery's public relations representative. Oil seeps from earthquake fissures.

Mother Nature threw a whammy at South Bay Refinery when she created underwater oil springs a few miles from shore

Dave Jones of El Segundo sits on a hot seat. Public relations representative for El Segundo refinery (Standard Oil of California), Dave is repeatedly refuting accusations that the refinery is responsible for tar that occasionally floats in to spoil the famous broad beaches in that part of Southern California. Because the refinery is the only one near the beach in that section, and because the company operates a submarine pipeline laid under the rolling surf, Standard of California is usually blamed for a trick that Mother Nature played many years ago. Several cracks on the face of the earth a few miles from shore have permitted oil to bubble up to the surface as far back as most men can remember. But the company gets the blame. Here's Dave's latest successful effort in placing the blame back on Mother Nature.

Reprinted from The Standard Oiler, published by Standard Oil Company of California, November 1957; William H. Jones, Editor.

"SOUTH BAY beach users were driven from the water today for the third day as oil and tar polluted the water and covered the sand.

"County lifeguards traced the oil to a submarine pipeline operated by Standard of California off its El Segundo refinery.

"Oil pollution Sunday was so bad that several people came out of the water completely covered with oil."

This news story, under a banner headline, ran in the July 30 edition of the Los Angeles *Mirror-News*.

This is known as a "repeater" — a story that pops up in the newspapers with regular frequency.

The story, and another one like it in the South Bay *Daily Breeze* brought on a recurrence of a long familiar headache to Dave Jones, public relations representative for El Segundo refinery.

It has been a headache as far back as 1928 when El Segundo Veteran Dave Peterson took a party of irate civic officials for a boat ride to witness the oil bubbling to the surface.

When things were bad 12 or 13 years ago, Standard even made a motion picture showing the oil slick on the ocean. This was shown to community and service clubs in the Southland and is still presented occasionally in that area's schools.

One seep, two miles off Redondo Beach and six miles south of the company's submerged loading line, is primarily a gas leak. Two others, off Manhattan Beach, leak mostly oil — and produce up to 600 gal a day.

When the latest commotion arose, Jones went into his oft-practiced routine again: He invited a reporter and a photographer from the *Mirror-News* and the *Daily Breeze* to go to sea with him and see for themselves the oil springs that bring Standard of California so much bad publicity.

The results were most rewarding.

The company gathered more space in good publicity than we had from the bad.

"Beach Scum Laid to Old Quake" headlined a subsequent issue of the *Mirror-News*.

"The next time oil and tar pollute the water in the South Bay, think twice before you place the blame," read the papers' opening paragraph.

Although the *Daily Breeze* writer developed a bad case of *mal de mer*, he turned in a sympathetic story for the company side.

"Fist Shaking in Vain; Tar Source in Sea Seep" the *Breeze* bannered.

"Next time you find yourself running into globs of oil on the beach, don't curse and shake your fist in the general direction of El Segundo," its article said.

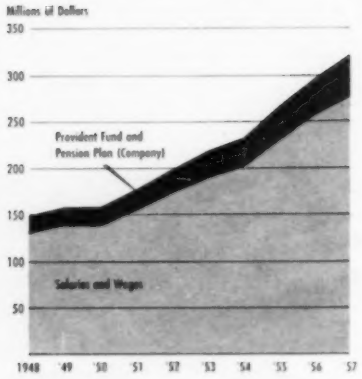
"Culprits responsible for the oil globs which keep messing up Junior every time he goes to the beach are two large natural oil seeps off Manhattan Beach.

"And they're making life miserable for the hard working public relations men at Standard in El Segundo.

"This disturbs Standard public relations men no end, for their company has no connection with the oil seeps."

All this publicity was fine with Dave Jones, but he always has a nightmare when the wind and tide are in the wrong direction. ★ ★ ★

More People—More Pay in Petroleum in 1957



Wages and benefits in the Shell Oil Company organization show typical growth among oil companies. Along with most other firms Shell granted a 6 percent increase in 1957.

INCREASE in personnel rose 2 percent in 1957 while payroll and benefits took a sharp 9 percent rise. The general 6 percent wage increase in 1957 came at a bad time for the petroleum industry. Many reports show serious concern that wages have gone faster than productivity, adding to inflation.

Here are some comments from 1957 annual reports:

Wages and Productivity

South Penn Oil Company: "Annual demands of labor for increased pay . . . have created a problem, serious for the national economy because of their definite inflationary effect and especially prejudicial to an industry which must cope with the problem of oversupply.

"This effect and its integral problems must be faced by industrial management with more careful study, determination and vigor."

Sinclair Oil Corporation: "Continuous increase in our costs of doing business . . . can be traced largely to labor costs — the labor costs we incur directly and the labor costs which of necessity attach to practically everything we buy. There is little doubt that labor rates have outstripped in many instances the increase in productivity made possible largely as the result of research and capital investment.

"An outstripping or even a disproportionate absorption by labor of the fruits of productivity tends toward a long-term sequence of rising prices, with all of the injustices evoked by an erosion of the values of savings, insurance, pensions and other fixed forms of income."

Benefits Rise

Cost of pensions and benefits apparently is growing faster than salaries and wages. This year Tidewater paid more than $12 million, or 22 percent of the direct payroll, for these benefits, including pensions, thrift plan, sickness and accident benefits, life insurance, etc.

No annual report questions this particular phase of personnel costs but doubtless many are making studies to determine future ability to meet the steadily increasing charge.

Development of pensions and benefits plans has followed naturally upon high personal income taxes (we'd rather have some money later — we can't save for the future with the government's cut so large) and upon full employment of the last several years (benefits influence employees to stay and help cut down turnover. Turnover among Texaco employees in the U. S. was 9.9 percent in 1957, for instance, compared to 45.9 percent for all manufacturing industries.)

Standard Indiana touches on the problem: "Recent years have seen companies in some basic industries committing themselves to cost-of-living and 'annual improvement' age increases well into the future without knowing what the future holds."

Education Supported

References to training and education were found frequently. Stated Continental Oil's report. "The company conducted several management problems courses for employees at the supervisory and administrative levels. These courses were taught on a case discussion basis by visiting professors from Harvard, Stanford, and other universities."

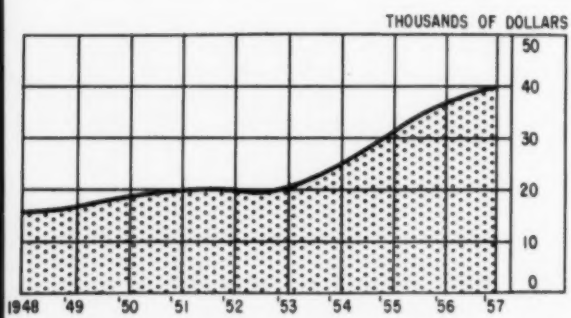
Sun Oil Company has an Educational Assistance Plan that is flourishing. The company pays tuition for completed courses. States the report: "During the school year 1956-1957, 325 employees successfully completed courses and received refunds totaling $18,800. This compares with $12,400 refunded to 227 participants the previous year."

Development of personnel abroad was reported by Socony-Mobil. "More than 200 middle-management and technical employees came to the United States from overseas affiliates in 35 countries for specialized training. Upon their return, many of them trained large groups of other employees."

Most oil companies provide scholarships and contribute to colleges and universities. One project that is stressed by several companies is an educational fund for employees' children. Phillips awarded 50 four-year scholarships to employees' children in 1957 and also made loans to students.

Standard of California reported: "The company continued its program of aid to education, which now encompasses a variety of activities ranging from financial support of students and institutions to informational programs designed to broaden public understanding of the petroleum industry."

One Ohio Oil Company approach is explained thus: "In order to promote a better understanding of the social and economic aspects of industry by educators, we have established an industry fellowship plan. A limited number of educators will be invited to accept summer employment with us and will be



Capital per employee is high in the petroleum industry. This graph from Atlantic Refining's report shows how it has climbed for that company in recent years, almost doubling in four years.

In one year
60 companies have

9% Higher pay & benefits
2% More employees
8% More shareholders

TABLE 1. PEOPLE IN PETROLEUM. 60 COMPANIES

Company	Holders of common stock† 1956	Holders of common stock† 1957	Employees, Avg. 1956	Employees, Avg. 1957	Payrolls & benefits ($1000) 1956	Payrolls & benefits ($1000) 1957
Amerada	9,053	10,467	2,117	2,148	—	—
Anderson-Prichard	5,250	5,900	931†	989†	5,848	6,658
Argo	35,000	38,500	—	—	—	—
Ashland O & R	34,303	37,960	4,600	4,800	—	—
Atlantic Refining	53,167	52,243	16,564	16,790	106,211	113,263
Aztec Oil and Gas	7,300	8,200	36	35	207*	249*
British American	31,587	31,206	7,397	8,064	35,086	44,184
Champlin	—	—	1,530	1,615	9,465	10,959
Clark Oil & Refining	3,588	4,068	1,800	1,843	4,469	5,469
Colorado Oil & Gas	6,400	7,497	575	630	3,521	4,069
Continental	29,504	30,504	9,837	10,118	64,600	70,300
Cosden Petroleum	3,769	7,131	732	947	—	—
Crescent	1,324	1,901	90	120	—	—
Delhi-Taylor Oil	10,000	10,400	646	685	4,106	4,671
Fifteen Oil Co	1,300	1,450	37	41	282	345
General American	2,872	4,489	624	642	3,101	3,269
General Crude Oil	1,102	1,053	220	221	1,450	1,514
Gulf Oil	85,225	90,404	57,700	61,100	265,139	311,326
Hancock	5,050	6,050	400	425	—	—
Honolulu Oil	4,489	4,736	631	655	4,765	5,179
Humble	—	—	19,001	19,604	151,197	167,382
Kerr-McGee	2,460[1]	5,643[2]	2,000[1]	2,750[2]	11,412	13,699
Leonard Refineries	4,476	4,693	706	670	4,260	4,978
Louisiana Ld. & Exp.	8,603	9,424	100	110	819	901
Midwest Oil	7,633	7,445	99	116	906	1,058
Monterey Oil	4,071	4,590	394	402	2,824	3,036
Murphy Corp.	1,700	1,611	412	585	1,978	2,713
Ohio Oil	41,108	43,726	6,637	6,582	41,800	44,256
Phillips Petroleum	102,906	117,619	27,461†	26,838†	177,560	192,506
Plymouth Oil	7,954	8,318	1,107	1,063	7,769	8,021
Pure Oil	40,456	43,534	12,102†	11,705†	68,832*	69,136*
Quaker State	6,047	6,306	1,586	1,474	7,491	7,599
Richfield Oil	11,924†	11,936†	5,914†	6,177†	37,272	41,287
Seaboard	2,520	2,500	770	769	5,200	5,400
Shamrock O & G	5,942	6,468	923	978	—	—
Shell Oil	19,727	19,685	39,903†	40,465†	293,657	317,367
Signal O & G	3,856	4,675	1,229	1,122	7,310	8,035
Sinclair O & G	114,806	115,502	25,125	25,191	153,663	167,335
Skelly Oil	5,965	6,087	4,750	4,826	27,255	31,352
Socony Mobil	181,605	202,000	44,500‡	45,200‡	317,800‡	355,800‡
South Penn Oil	10,201	10,187	2,397	2,390	11,083	11,223
Standard Calif.	137,381	148,315	38,854[3]	40,121[3]	250,071[3]	276,850[3]
Standard Ind.	143,200	148,400	52,010†	49,680†	358,600	370,100
Standard N. J.	403,000	462,552	156,000	160,000	905,600	993,400
Standard Ohio	38,633	39,440	11,514	11,587	67,559	69,509
Sun Oil	22,417	24,340	18,939	19,090	118,309	124,600
Sunray Mid-Con	97,634	103,810	5,955	5,704	34,863	36,942
Superior Oil	1,589	2,300	3,139	3,046	—	—
Texas Co.	131,034	135,164	52,587	53,340	272,821	307,258
Texas Gulf	7,700	8,400	216	225	1,612	1,747
Texas Pacific	5,705	5,564	458	462	—	—
Tidewater Oil	18,252	19,796	9,619†	9,763†	55,787	61,785
TXL Oil	7,500	8,000	43	55	—	—
Union of Calif.	50,000	52,000	8,823	8,543	63,958	65,435
Union O & G of La.	1,450	1,450	393	413	2,574	2,736
Universal Consolidated	2,500	2,500	100	120	727	775
Utah Southern	1,500	1,550	27	20	—	—
White Eagle Oil	3,100	3,400	722	648	—	—
Wilcox Oil	1,713	1,929	134	139	1,051	827
Woodley Petroleum	1,564	1,641	80	79	539	592
TOTAL	1,990,115	2,156,653	663,196	673,920	3,972,409	4,347,095

NA — Not Available
*Exclusive of benefits
[1] June 30, 1956
[2] Sept. 30, 1957
[3] Western Hemisphere only.
†At year end
‡U. S. only

given the opportunity to make a . . . study of our operations."

Safety Makes Gains

Safety is another frequent topic when employees are discussed in annual reports. States Sohio: "The frequency rate of disabling injuries dropped for the eighth consecutive year — to 2.07 injuries per million manhours, the lowest in Sohio's history. There were about half as many injuries in 1957 as occurred in 1956."

Sinclair points out: "In planning work procedures, the first consideration at Sinclair is the physical safety and health of the employee. Through constant on-the-job training and education, steady progress in safety has been achieved."

Stockholders Increase

Number of stockholders for the companies in Table 1 reach more than two million (many, of course, are duplicates). This is 8 percent above 1956.

Jersey Standard now has 462,552, largest number of any oil company and third among all U. S. corporations. Sunray Mid-Continent topped 100,000 for the first time and Socony went over 200,000 stockholders.

Corporate Citizenship

Standard Oil Company (Indiana) in its report presents an interesting description of the "corporate citizenship" — the principles that guide its actions. It is well worth reading. After you read these excerpts you might speculate on the change in "corporate citizenship" in the last 10 years.

"Every corporation is, by law, a person in the courts. It can sue and be sued. But a corporation ought to be a person in a sense much broader and more meaningful than that. It should be a person in the sense of being a good citizen of the community. . . .

"We recognize that we have a duty, along with all other citizens, to help, through organized agencies, in relieving the distress of the unfortunate.

"We have been concerned that we should help in erasing or at least alleviating disease. . . .

"We have accepted it as our duty to help forward the education that is a mainstay of a dynamic democracy. . . .

"We have recognized an obligation to help train and inspire the youth of today . . . to the ways of a good life. . .

"We have acknowledged that we should share in the giving of time and effort, as well as of money, to movements for civic betterment. . . .

"Basic as these responsibilities are, however, a corporation has obligations even more basic. To its customers, it must furnish good products at fair prices. To its employees, it must provide the conditions, opportunities, and rewards that promote and recognize loyal and efficient service. To its stockholders, it owes a fair return on their investment and a constant endeavor to protect and enlarge their property. To suppliers and all others with whom it has business relations, it has a responsibility for considerate and ethical dealings. Finally, to society as a whole it owes a fair accounting of its activities, and the articulate expression of its views and philosophy with the end in view of making available an adequate basis for evaluative judgment." ★ ★

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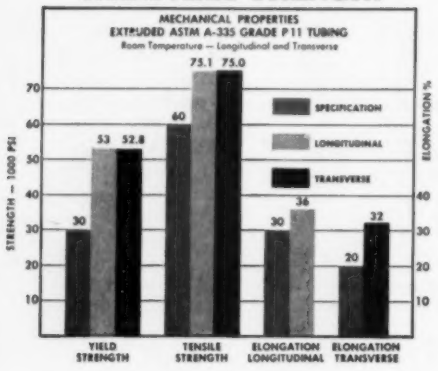
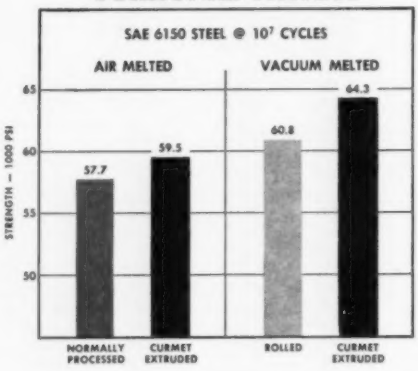
CURMET

Ferrous, non-ferrous and titanium alloys give you the properties you need for positive performance.

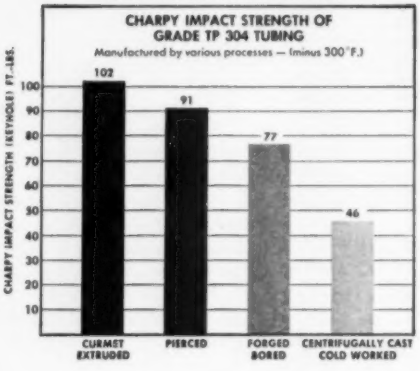
TRANSVERSE STRENGTH



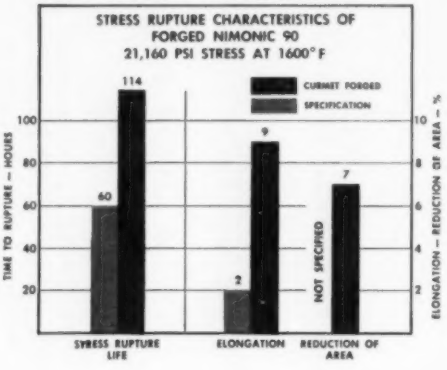
TORSIONAL FATIGUE



IMPACT STRENGTH



ELEVATED TEMPERATURE



Above are examples of physical properties resulting from CURMET Processing. Consult CURMET for data to meet your design problems. CURMET Processing has been developed by the Metals Processing Division of the Curtiss-Wright Corporation.

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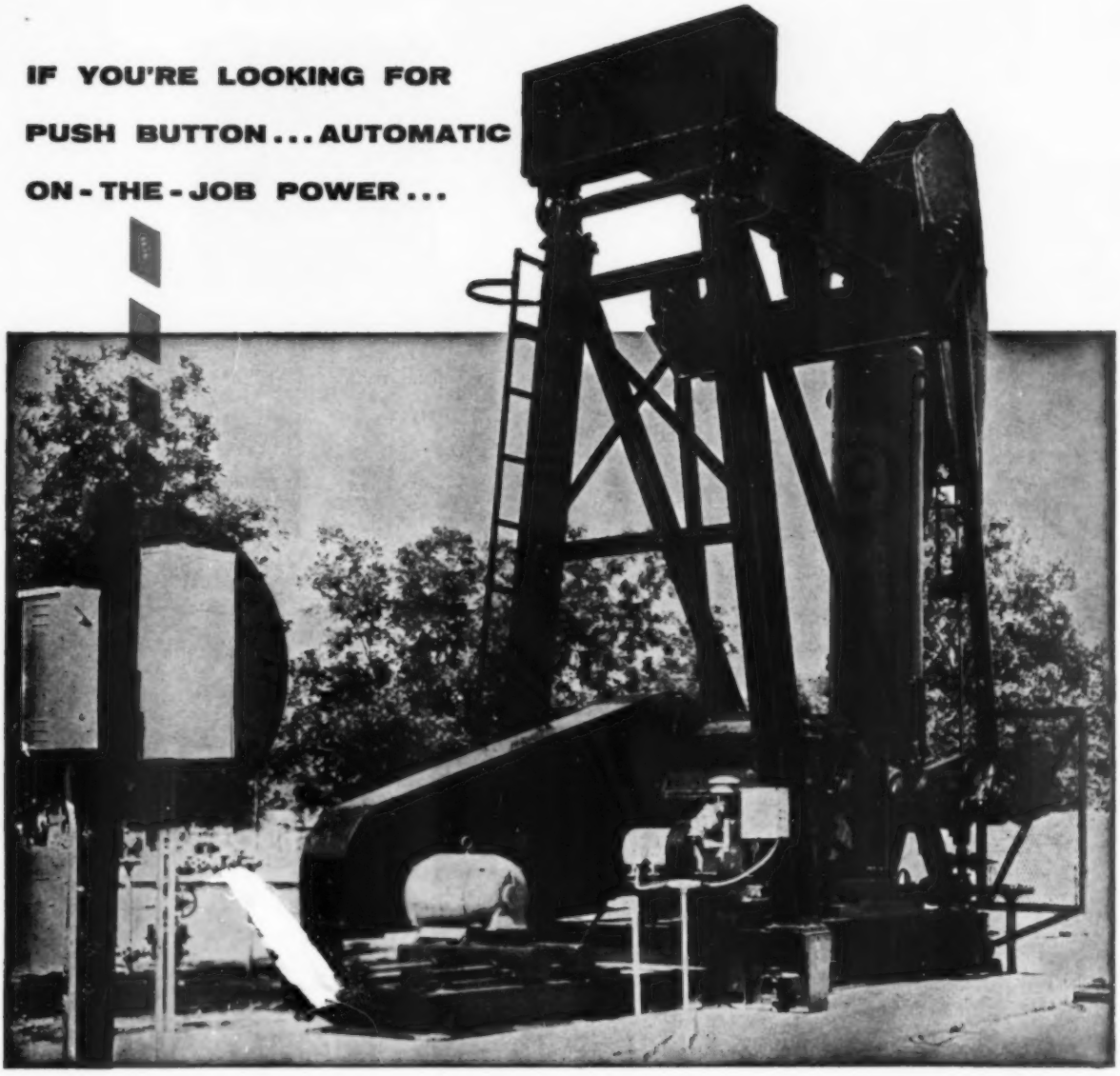

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Automation is the key word in more efficient and progressive management today. And when you think of *automation* you must associate it immediately with UTILITY ELECTRIC POWER. Only UTILITY ELECTRIC POWER provides the complete, fully automatic features of automation in oil field production. The evidence is so impressive in favor of UTILITY ELECTRIC POWER that all companies – who consider themselves progressive – will want to know how they can benefit from this modern, efficient power. Call the sales engineer of your Utility Electric Service Company for complete facts.

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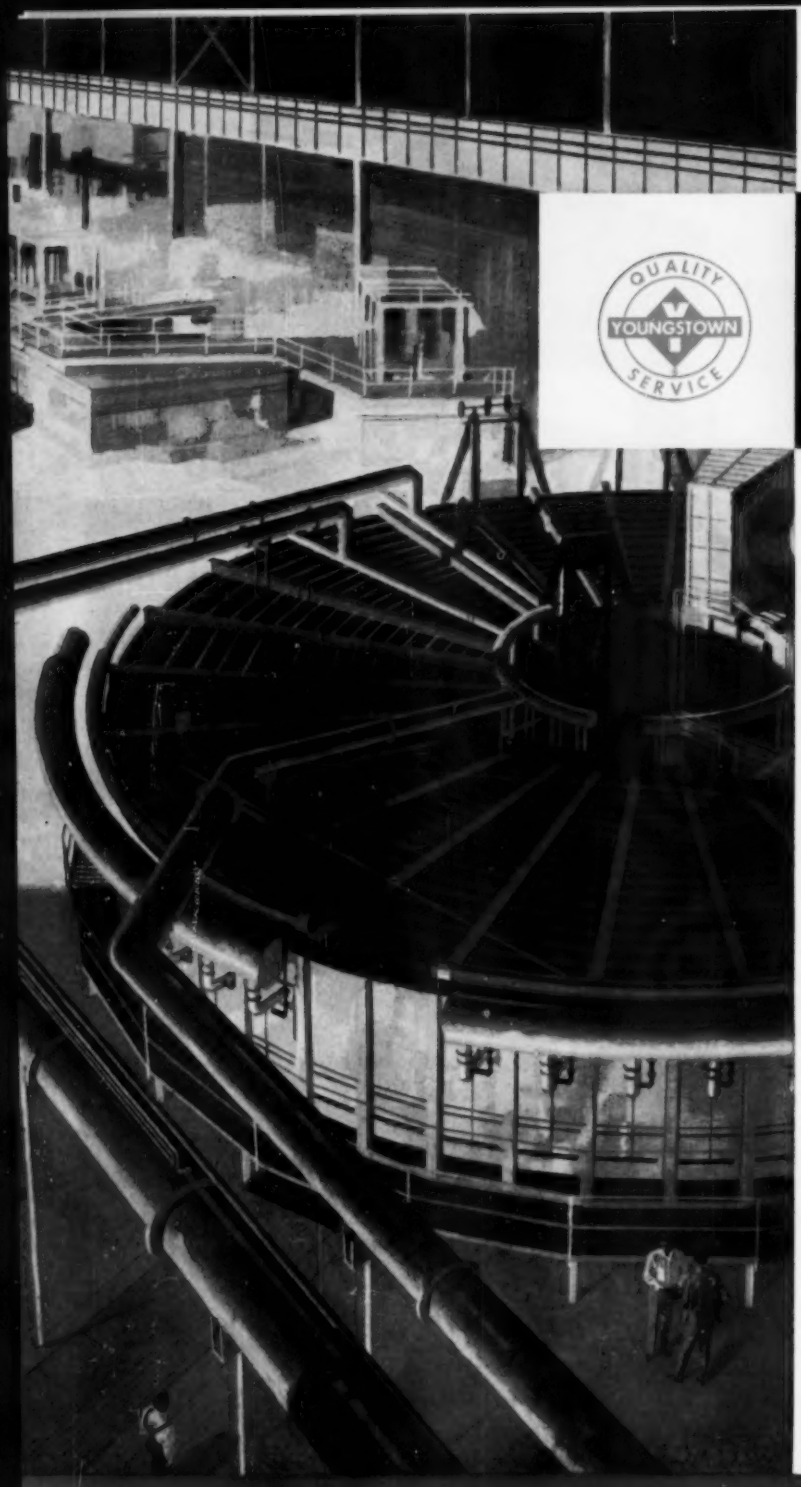

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LET'S TALK PIPE

World's largest rotary billet heating furnace at Youngstown's new Indiana Harbor plant.. world's most modern tube mill.

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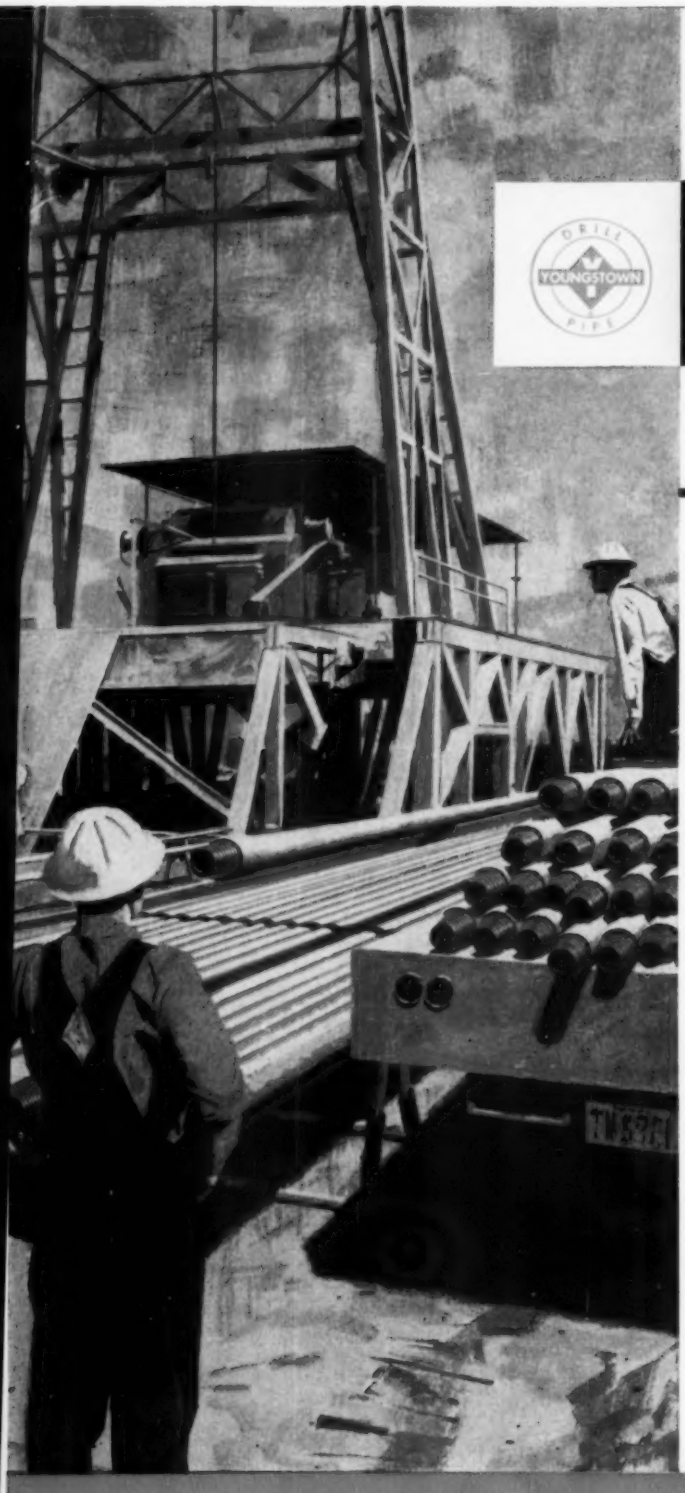
..THE PIPE WAREHOUSE OF THE **OIL WORLD**

..THE PIPE WAREHOUSE OF THE **OIL WORLD**



Youngstown pi

ENGINE
FOR THI

LET'S TALK DRILL PIPE

..2⅜" through 5½" API sizes..upse
for flash weld..API and special threa

GRADE D	YIELD STRENGTH 55,000 psi
YOLOY	YIELD STRENGTH 70,000 psi
GRADE E	YIELD STRENGTH 75,000 psi
X-95	YIELD STRENGTH 95,000 psi
P105	YIELD STRENGTH 105,000 psi

Developed by Youngstown and included in
five API grades are lightweight drill pipe
crease rig depth range and special fatigue,
and torque resisting pipe for deep holes. Ea
designed for more rotating hours under sp
drilling conditions. This wide selection let
drill with Youngstown drill pipe to all depth
in all formations with maximum efficie
maximum economy.

This drill pipe is made for all types of tool j
so specify the one you want..and have
Youngstown quality too.

LET'S TALK TUBING

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Youngstown tubing is available in all API
and grades for every well condition. Co
quality-control assures fast make-up, high
strength and smooth, free-flowing interior

These familiar ORANGE BA

pipe is delivered..

EERED
IE JOB

Today's pipe strings must be *designed for the job* for maximum safety and economy. Here's where your Continental-Emsco and Youngstown *pipe team* steps in. Your C-E man *knows* local drilling conditions . . your Youngstown pipe engineer *knows* pipe. Together, they can recommend the pipe grade best suited for you . . performancewise . . pricewise. And Continental-Emsco intransit stocks plus strategically placed *local* pipe stocks assure fast delivery.

LET'S TALK CASING

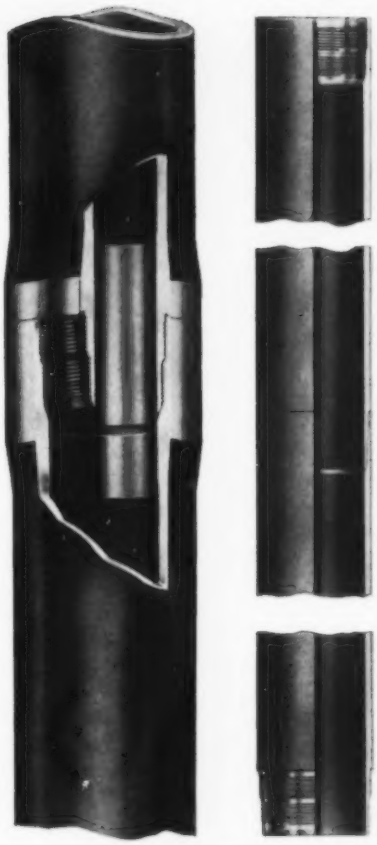
. . Complete range of sizes . . API grades H-40, J-55, N-80 and P-110 made in the world's most modern tube mill

SPEEDTITE . . *Streamlined joint developed for today's greater depths and pressures.*

SPEEDTITE, proved for over 20 years, gives full clearance with the extra strength needed to support heavy deep-well casing strings. SPEEDTITE joints provide 100% pressure seal against both internal and external pressures . . completely leak proof up to and beyond the casing's yield point.

FLUSH JOINT . . *Designed for tight holes and for liner pipe installation.*

FLUSH JOINT is an extremely strong casing joint. Because of its positive shoulder action, these casing joints transmit high torque loads without creeping and can be broken-out and made-up repeatedly without damage to the threads. Smaller OD allows use of one size larger FLUSH JOINT casing than with collared casing. In sloughing or caving formations, the running speed of FLUSH JOINT is of great importance. It can be run through packers at high speeds, under high or low pressures without damaging them.

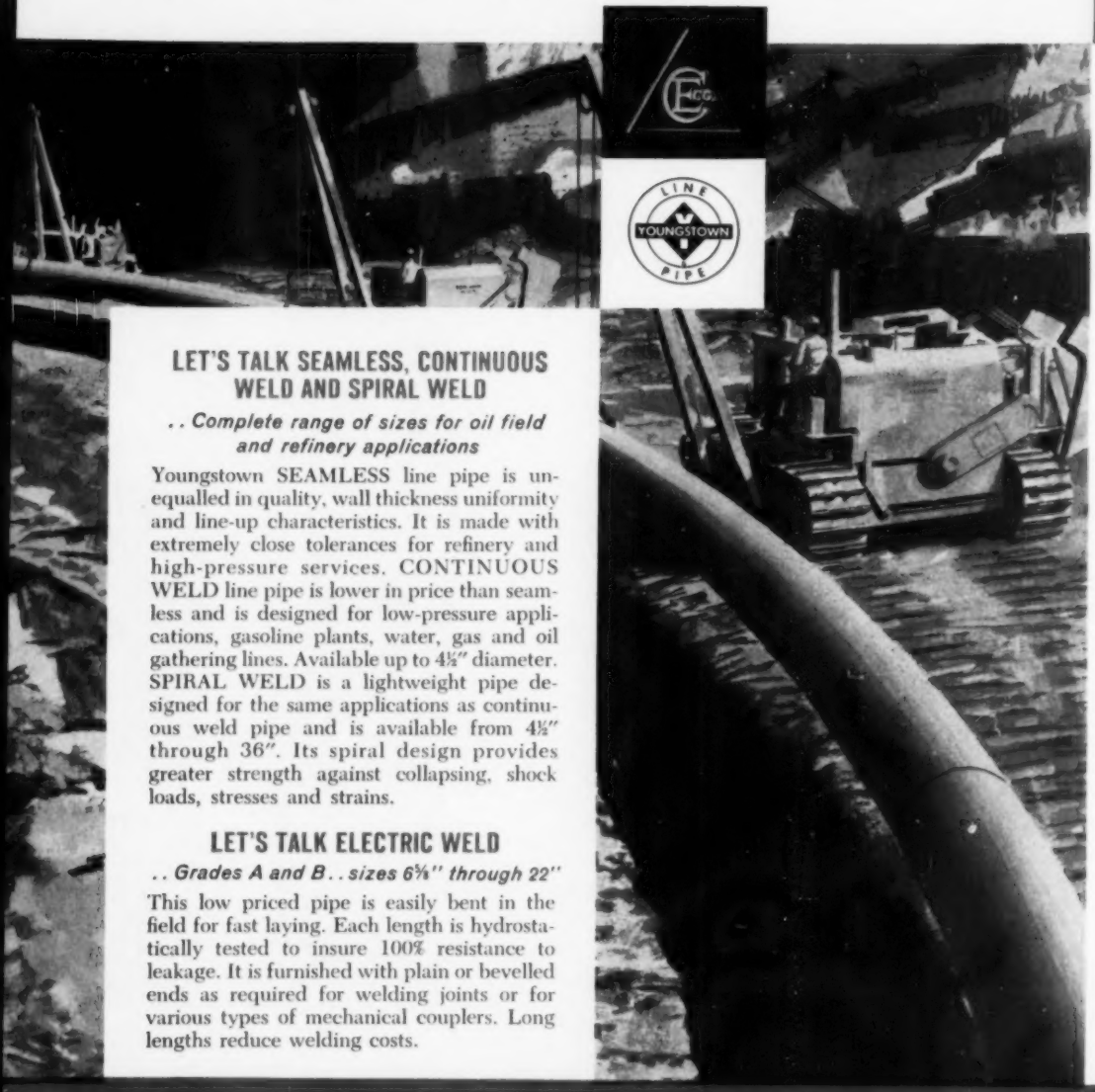


SPEEDTITE FLUSH JOINT

BANDS say TOP QUALITY

KEEPING OIL AND GAS ON THE MOVE

Your Continental-Emsco and Youngstown *pipe team* stands ready to recommend the right pipe for your pipe line installation, whether for transmission lines, gathering lines or water-flood piping systems. This team is backed by a complete range of grades and sizes in all wall thicknesses and in single or double random lengths.



LET'S TALK SEAMLESS, CONTINUOUS WELD AND SPIRAL WELD

. . Complete range of sizes for oil field and refinery applications

Youngstown SEAMLESS line pipe is unequalled in quality, wall thickness uniformity and line-up characteristics. It is made with extremely close tolerances for refinery and high-pressure services. CONTINUOUS WELD line pipe is lower in price than seamless and is designed for low-pressure applications, gasoline plants, water, gas and oil gathering lines. Available up to 4½" diameter. SPIRAL WELD is a lightweight pipe designed for the same applications as continuous weld pipe and is available from 4½" through 36". Its spiral design provides greater strength against collapsing, shock loads, stresses and strains.

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This low priced pipe is easily bent in the field for fast laying. Each length is hydrostatically tested to insure 100% resistance to leakage. It is furnished with plain or bevelled ends as required for welding joints or for various types of mechanical couplers. Long lengths reduce welding costs.

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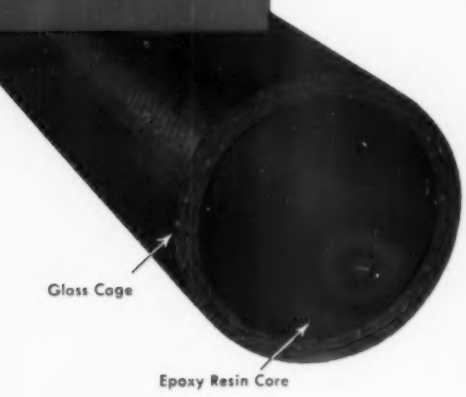
LET'S TALK SPECIALTY ITEMS

Talk "special piping applications" with your Continental-Emsco pipe men. Their recommendations of special pipe materials will solve sweet, sour, salt water corrosion and paraffin problems. Special pipe diameters and fittings are available for unusual gathering lines, dual-zone pumping, water flooding and other applications. Let C-E tackle your tubular problems with experience, quick delivery and warehouse facilities.



FIBERCAST.. *A high-pressure, high-temperature modern pipe for use in oil fields, chemical and petro-chemical plants*

FIBERCAST is made in API diameters and up to 21′ lengths. It is lightweight and furnished with the most complete line of fittings ever offered in a non-metallic pipe line for fast, leakproof hook-ups.

Drawing shows the glass cage made of continuous fibers braided into a glass sleeve of multiple seamless layers. This cage gives FIBERCAST its unusually great axial strength. Inner epoxy resin core is centrifugally cast to impregnate the cage as well as form a corrosion resistant, free-flow interior wall.

These plastic pipes are available in all standard iron pipe sizes.. up to 20′ in length. They have long lasting qualities in low-pressure, low-temperature, corrosive installations. GREEN TRIANGLE X-TRUDE, made of high-grade extruded thermoplastic, is lower in price and more flexible than PVC pipe. GREEN TRIANGLE PVC is a heavy-duty, polyvinyl chloride pipe.. unexcelled in resisting corrosion. It is one-half the weight of aluminum.. one-sixth the weight of steel.

GREEN TRIANGLE X-TRUDE AND PVC PIPE..

Designed for low-pressure, low-temperature flow lines, salt water disposal

Aluminum pipe is highly recommended for gathering lines where its resistance to corrosion gives it exceptionally long life. Its light weight and flexibility make it easy to lay. Tool pushers find that aluminum pipe, used for temporary fuel and water lines, is fast laying and economical because of its light weight.

ALUMINUM PIPE..

Light weight.. corrosion resistant

TUBULAR NEEDS..

LET'S TALK PIPE SUPPLY AND SERVICE

We know pipe. We have the pipe grade and size to meet every oil field piping need efficiently.. economically. For *pipe engineering* Youngstown field engineers working in conjunction with C-E men are available to make pipe recommendations for those special, ticklish jobs. Continental-Emsco stores are handy, convenient supply points for valves, fittings, gauges, pumps, compressors and the thousand and one items needed for pipe installations and servicing.

CONTINENTAL-EMSCO..

Supplies pipe to all branches of the petroleum industry.. **WORLDWIDE**

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Continental-Emsco is also a distributor for Mannesmann Tube Company Ltd. in Canada.

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At strategic locations, pipe shipments are trucked to your lease for fast delivery.

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Youngstown's tube mills are located at Indiana Harbor, Ind. and Youngstown, Ohio.

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T830

...Go CONTINENTAL-EMSCO

How to Win an Economic War

1. **Produce good products**
2. **Organize Central Research Institute**
3. **Invest abroad**
4. **Trade all over the world**
5. **Sell the whole package**

J. B. O'Connor

IN AN ECONOMIC WAR, we are the soldiers. By "we," I mean the businessmen who run modern industry.

The immediate objectives, in this war, are the markets of the world.

If we look at this year's statistics, we may be discouraged about our success in the economic war. We read that for the first time, America is being outproduced by the rest of the world in automobiles. In some places, our markets are being taken over by Soviet suppliers; foreign mineral resources which have been in our control are slipping from our hands; we are being out-done in research and heavy industrial development. All of this seems very grim — as if we had started losing the battle for men's souls by losing the "Battle of the Marketplace."

The fact is we never were winning it.

Not very long ago, in Paris, a Frenchman said to me, "The things which America has offered the rest of the world can be summed up in three words . . . dollars, Coca-Cola, and nylons." This is a serious indictment. This Frenchman's words were, to be sure, an over-simplification.

In contrast, our competition is merchandising a philosophy, a political outlook, and a good bit of clever diplomacy with each sale they make.

This upsets us, and it should. Not because our competitors are so sly. What should upset us is the fact that *we* have turned out to be such low-caliber salesmen.

We do not know our product. We do not sell it well. We fail to merchandise the "whole package."

This is a condensation of a speech of Mr. O'Connor, president of Dresser Industries, Inc., accepting the honorary degree of doctor of commercial science from St. Bonaventure University, St. Bonaventure, New York, May 1, 1958.

Here are a few of the specific tasks which face business.

No. 1

Number one is a fundamental, down-to-earth, dollars-and-cents fact. **We must be able to produce a good product for a reasonable price.** We are not doing this. The fact has become painfully clear that once they have the "know-how," Europeans can match us point-for-point on quality and deliver the product more cheaply.

We must start thinking realistically. Labor must adopt a more reasonable stand, enabling the manufacturer to put out a product with a buyable price tag, and at a fair profit. Labor must stop adding *non-productive* cost to the price tag if we are to stay competitive in the world market. Customers do not buy overtime, they buy products.

No. 2

The second item on my list pertains to management.

If we are to retain technical superiority in the world, **we must be able to compete with the science and research of the Soviet Union** and its satellites. I would like to go on record as saying that I believe this can be done effectively only by joint cooperation in the American business community.

It is my firm belief that U. S. industrialists should pool their resources to establish an institute to function in the same way as the Soviet Academy of Science. We should have at the service of this nation a Central Research Institute through which will be funnelled all of the technical and scientific data available in the entire world. This institute should do our long-range planning and research.

We do not have this. We *must* have it or we will be out-done by our competition. I submit this conviction to American industry, in the sincere hope, that we may all act together before it is too late.

J. B. O'Connor (left), president of Dresser Industries, Inc., is greeted upon arrival at Mt. Alton Airport by J. N. Mackendrick, president of Clark Bros. Company, a Dresser subsidiary. O'Connor arrived to receive the honorary degree of doctor of commercial science from St. Bonaventure University.

No. 3

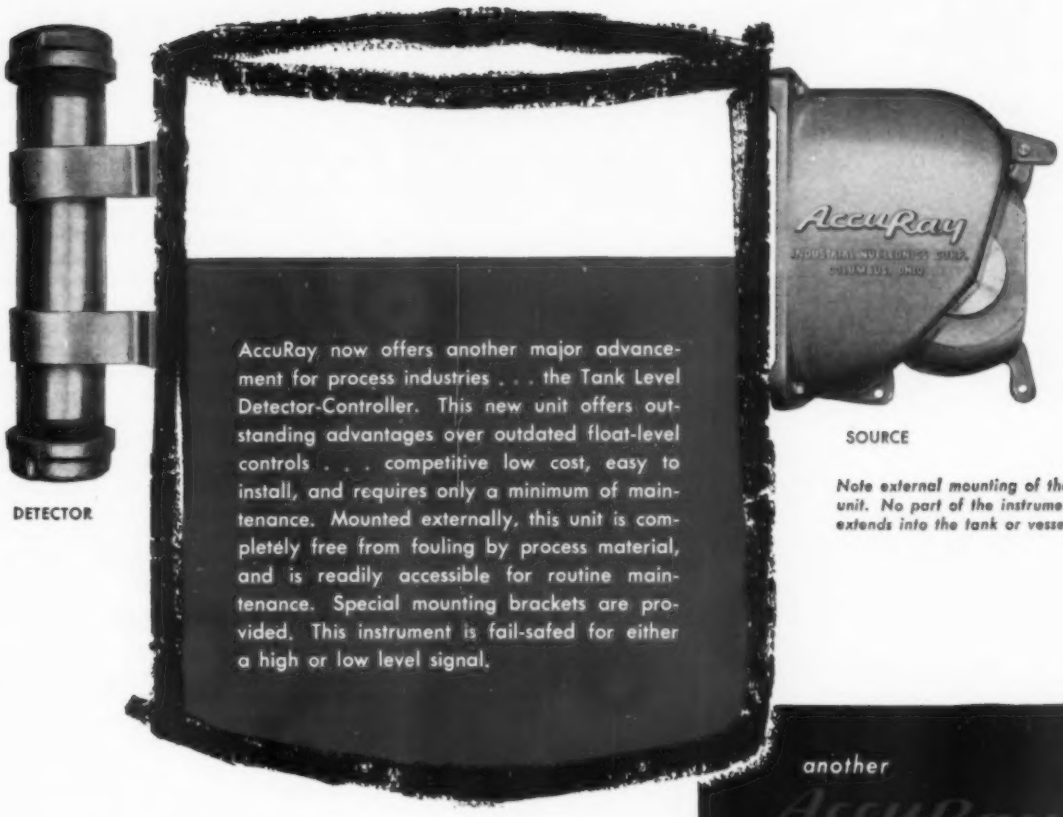
My third point deals with American capital investment in the rest of the world.

This is one of the great challenges before us now — **to have the courage, the vision, and the imagination to invest abroad.** The task before us is to give more freely of our resources and technical know-how in building up other nations.

It is too easily forgotten that in the days of our infancy as a republic, it was the investment of foreign capital which built the United States into a first-class power. We seem to have the impression that the world's modern industry originated in the U. S. sometime after the war between the states.

Nothing could be further from the truth. Europe, already industralized for generations, gave us our start. Not only did she give us the technical know-how to create our vast industrial

AccuRay TANK LEVEL DETECTOR-CONTROLLER


AccuRay
AccuRay now offers another major advancement for process industries . . . the Tank Level Detector-Controller. This new unit offers outstanding advantages over outdated float-level controls . . . competitive low cost, easy to install, and requires only a minimum of maintenance. Mounted externally, this unit is completely free from fouling by process material, and is readily accessible for routine maintenance. Special mounting brackets are provided. This instrument is fail-safed for either a high or low level signal.

DETECTOR

SOURCE

Note external mounting of the unit. No part of the instrument extends into the tank or vessel.

another AccuRay® advancement for process control

The AccuRay Tank Level Detector-Controller can be used in two ways. It can be installed horizontally to provide a relay closure signal when the level rises above or falls below the level of the detector; or it can be installed vertically so that both a high level and a low level signal can be provided from one instrument. Accuracies can be maintained to plus or minus 1/16". The radiation source is installed either opposite the detector on the tank, or across a chord of the tank. The design of the source housing provides more than adequate shielding. Design of the instrument is in accordance with accepted standards for both explosion-proof and weatherproof operation.

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Maximum digging depth: 26 FEET with KOEHRING 1-YARD HOE

Combining long, deep reach with heavy-duty digging strength, Koehring 1-yard 405 hoe delivers big-yardage output on pipeline trenches, footings, slush pits and other below-grade excavations. It reaches a long way down, 22½ feet below crawlers with standard boom — *26 feet deep with special boom* — comes up with a full load every pass, in any kind of dirt or rock. There are variable settings on dipper arm — cutting angle is easily changed to best suit digging conditions and type of cut. Big 1-yard dipper makes a wide cut — 43 inches over side-cutters. During the dig-and-swing cycle, close-coupled dipper pulls up tight to boom, avoids spillage as boom is raised. Long reach puts spoil bank well back beyond edge of cut.

Light lever-pull

For all its powerful, fast action, this heavy-duty 405 is an operator's dream! Big power clutch requires only 1/10th the lever-pull of a comparative-size manual clutch — yet retains accurate "feel" of load. Automatic traction brakes also simplify operation — are engaged at all times, except when tractive power is applied. They lock and hold the 405 when working or parked. Maintenance is simplified, too. There are only 2 main shafts in the 405's upper machinery.

Other work capacities:

The 405 readily converts to 1-yard shovel, handles 1 to 1½-yard clamshell or dragline buckets on a wide work radius — has 20-ton lift capacity as a crawler-mounted crane. Your Koehring distributor has more information on this *extra-capacity* 405 that will be of interest to you. Call him — or write.

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COMPANY..... DIV.....

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CITY..... STATE.....

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complex, Europe dug deep into her own wealth to finance our business endeavors.

Let us, with private American capital, finance and build the dams, the steel mills, the communications systems and the factories which other nations so sorely need to improve their standard of living. Let us give back of the bounty which was once bestowed upon us. Let us show our faith in the future of other nations, in the same way that Europe once showed her faith in us.

And, as a hard-headed businessman, I insist that this will pay us dividends. We must build up the buying power of these countries if we are to create a market favorable to ourselves. This has been clearly demonstrated in the case of Mexico which has become our leading customer.

No. 4

My fourth point has to do with customer relations. **All the people of the world should be our customers.**

The best way to know people is to trade with them. There is no surer way of learning how a man thinks than to get your feet under the same table in a horse-trading session. You can get to know and respect a man very quickly by the way he drives a bargain, and the way he keeps his promises.

Americans often do not give foreigners enough credit for their abilities. But we must learn to acknowledge the abilities of others — and meet the competition head on.

American businessmen always tend to think in dollars. But we must learn to trade in the customer's currency, whether it be money, marbles, or chalk. By this means, we will be able to move our goods into areas where there is a crying need for them. Let their need be the means whereby both parties benefit.

Briefly, the point is this. You must come to know and understand other peoples according to *their* values. Recognize differences, without making the moral judgment that since this is not American, it is therefore inferior.

No. 5

And this brings me to the fifth and last point . . . **we must sell the whole package.**

I believe that we have something to sell besides "dollars, Coca-Cola, and nylons."

What we have to offer the world is the means of preserving all that is fine and good in western civilization. This nation of ours represents the result of more than *three thousand* years of inspired thought and dedicated work. In America, all the finest hopes and aspirations of Greece and Rome, of Ancient Israel and of Christendom, have blended together as one seed to produce a single glorious flower — human liberty.

That is our American heritage. For we were truly the first nation in the history of the world which enshrined as its political ideal, the dignity of the individual. We were the first to provide a way of life in which free men could live in freedom as brothers, respecting one another in equality, as children of God.

History does not *long entrust the care of freedom to the weak* and the timid. It is in *your* hands, now, to take this freedom and sell it proudly to the rest of the world. According to the dignity with which you wear the great gift of your individuality . . . and according to the integrity with which you do your work, so will your fellow man respect you, love you, and reward you. ★ ★

OPERATIONS RESEARCH Through Committee Action

Excerpts from an address by Donald Lichty, Nekoosa-Edwards Paper Company, presented at the annual National Conference of Controllers Institute of America, November 2, 1957.

An organization to handle operations research is generally set up in one of two ways. It can be a staff department and, as such, collect and evaluate its own data, apply it to the problem and make its recommendations to management. The second way is to draw upon your present personnel and carry out the work through committee action. This is the way we have set it up; we believe it has many advantages:

1. **It is less expensive to start.** People trained in operations research are scarce and expensive. One such person is useless, because the development comes from exchanging ideas, so a minimum of two, plus a staff, is needed. By following the committee route, a company can choose people from the different divisions of its own organization. They already have the basic knowledge of the industry and the detailed knowledge of each division's operations. This gives them a head start in tackling any problem to be studied.

2. **Communications problem is simplified.** This is one of the most difficult areas to overcome. Facts pertaining to the problem, formula applications and limitations of the problem must all be discussed freely. This exchange is necessary not only between the industry and the mathematicians, but also between management and operating personnel. We feel that this is much easier to accomplish through committee action than through a staff organization.

3. **Necessary data is more readily available.** Each representative on the committee knows the sources of data in his department, how it is to be used in the study, and any possible shortcomings it may have. Knowing these three things at the beginning can often expedite the study by eliminating false starts that could develop through the staff-type operation.

4. **Recommendations are more readily accepted.** We have found that individual departments will often modify their existing practices in accordance with the results of findings, so that when the final report is made, the plan will already be in operation. On the other hand, when a complete plan is offered as a package, there is often some hesitancy on the part of some division managers to accept the plan without study and review, which often delays installation.

5. **Application of operations research studies can be more direct.** Through committee action, work is generally focused more sharply upon the problem under study.

6. **Committee action can improve management.** This is the most important point. As more people from an organization become aware of the concepts and tools of operations research, they will apply these concepts to day-by-day decisions — not only improving the overall company performance but also broadening themselves for more important management jobs.

We use operations research techniques on a regular basis. We strongly feel that the concepts and tools it has made available are potent forces to aid in decision making. Through what is known as the linear programming technique, we are able to plan our machine load three months in advance. Through mathematical modeling, we are able to "operate" each system or function on paper to determine optimum solutions at a much smaller cost than physical or actual manipulations would involve, and with equally reliable results.

One of the most attractive features of operations research is the fact that a definite dollar sign can be placed, in advance, upon a course of action. If there is any hesitancy of acceptance, or resistance to change, the dollar difference is something everyone understands. ★ ★ ★

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A Guide to Books

Brainstorming, *by Charles Clark, published by Doubleday & Company, Inc., 575 Madison Avenue, New York 22, New York. Pages, 262. Price, $4.50.*

Besides gasoline additives Ethyl Corporation has given us many ideas. One of these — brainstorming — has become a recognized method for producing ideas. Now we have the first full-scale presentation in a book entitled "Brainstorming," by Charles Clark. Clark was assigned by Ethyl Corporation's public relations department to demonstrate the technique to the oil industry. He has done an excellent job. He shows every step in the new technique and then gives abundant proof that brainstorming pays off in histories of companies and individuals that used brainstorming to produce valuable ideas.

There have been some who have questioned the all out belief in brainstorming but as a general rule what has been questioned was the way it has been used — whether there has been a follow through and whether some types of scientific minds would not do better on a slower tempo. There is no question, however, of the usefulness that others have found in brainstorming.

This looks like a "must" book on the management level.

Conservation in the Production of Petroleum, *by Erich W. Zimmermann. Published by Yale University Press, New Haven, Connecticut. Pages, 417. Price, $6.*

This is a study of oil and conservation programs that have developed in the U. S. from the time of the late 1920's and early 1930's. Oil conservation measures are reviewed from various standpoints: Historical, legal and purpose. The author, although pointing out problems and weaknesses, finds the program a sound contribution to the orderly government of one of the most vital industries in the nation. It is a book for careful study, close reading and ready reference.

Landman's Legal Handbook. *by the Denver Legal Staff of Continental Oil Company. Published by F. H. Gower, 2240 Mile High Center, Denver 2, Colorado. Pages, 250. Price, $4.50, supplements, $.65.*

This is an excellent book of procedures, taking the landman from acquiring an oil and gas lease until the attorney has examined and accepted the title for drilling. It covers fee, federal, Indian, state and county leases and the examination of records pertinent to such leases. Proper forms of legal instruments are suggested in matters of leasing, federal unitization and many other common situations. Supplements are available for states of Colorado, Montana, Utah, and Wyoming.

Safety in Welding and Cutting, *published by the American Welding Society, 33 West 39th Street, New York 18, New York. Pages, 50. Price, $2.*

This is a complete revision of the AWS-ASA Z49 standard wherein the entire field is covered in great detail. Fire Prevention and Protection indicates the basic precautions to be taken and also the additional precautions necessary when the nature of the work is within certain categories. Protection of personnel is covered very extensively and includes the precautions necessary when using the newer welding processes. Eye protection is particularly stressed and recommendations are made for adequate shielding from flying particles and harmful rays. The precautions necessary when welding with inert gases are fully detailed and suggestions are made for the protection of fellow workers. Considerable space is devoted to the safe handling of fuel gas and oxygen cylinders.

Exploration Geophysics. *by J. J. Jakosky. Published by Trija Publishing Company, 2500 West Coast Highway, Newport Beach, California. Pages, 1200. Price, $12.50.*

Engineers, geophysicists and others concerned with geophysical exploration techniques will be especially interested in the revised edition of Jakosky's text.

Jakosky worked with 39 other authorities in developing and writing the book. With over 1200 pages and 715 illustrations, it covers every phase of modern exploration methods, even including such subjects as permit, trespass and insurance problems.

The Geology of Parker County, Texas, *by Leo Hendricks, published by the University of Texas Bureau of Economic Geology, Austin 12, Texas. Pages, 67. Price, $1.50.*

The publication gives stratigraphic classification of Pennsylvanian beds and Cretaceous rocks. Wholetone plates picture the limestone beds of Hill Creek, Meek Bend and Brannon Bridge. Other illustrations show Brazos River sandstone, Grindstone Creek shale and lower Trinity conglomeratic sands. It features a large geologic color map of the area.

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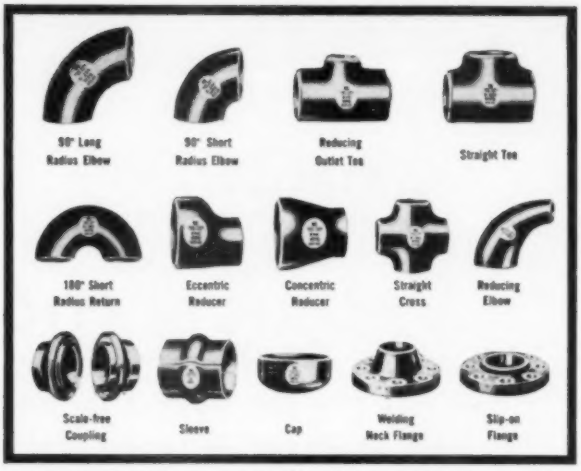

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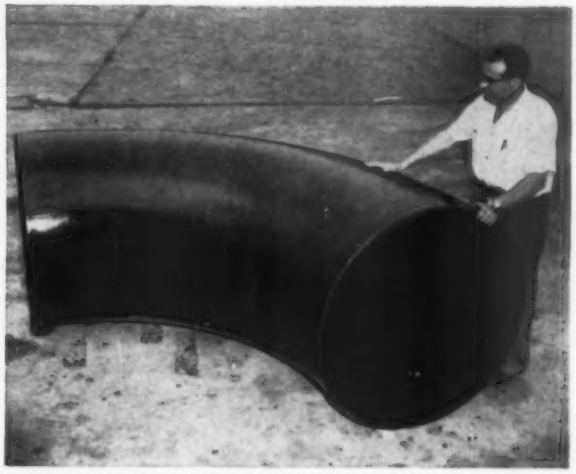

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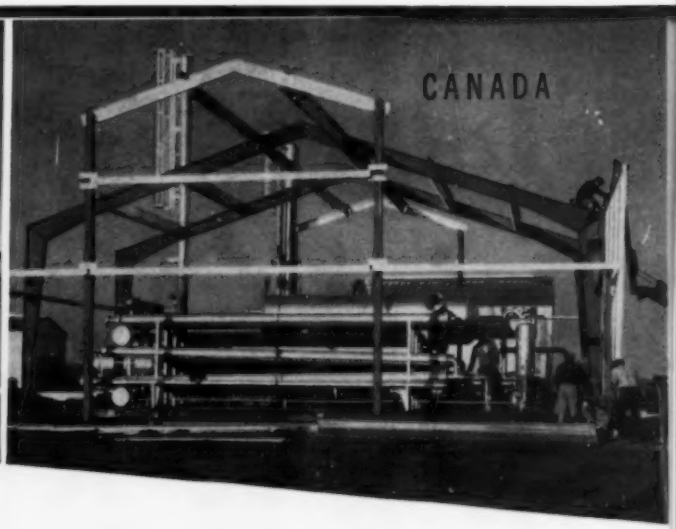

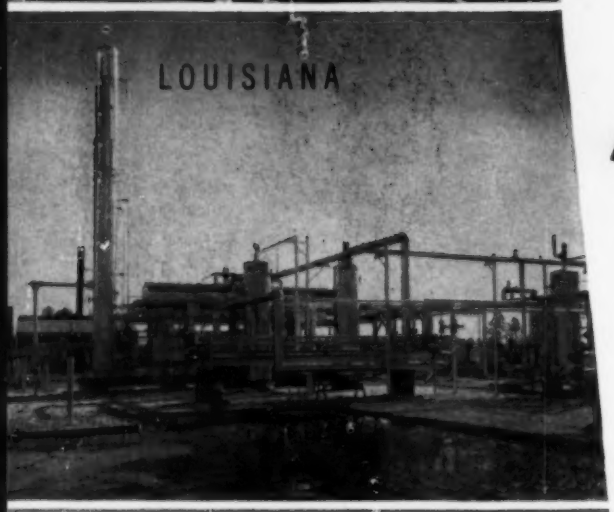

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Laugh with Barney

Recently the following testimonial was received by a patent medicine concern: For nine years I was totally deaf, and after using your ear salve for only 10 days, I heard from my brother in Alaska.

As the British train was about to depart from the station of a small English country town, the American passenger heard a British gentleman say to his host, who was seeing him off, "thanks, old fellow, I've had a marvelous week-end. You are a jolly host, and your wife — truly the best bed companion I've ever had." With that he shook hands with his host and boarded the train.

The American shook his head from side to side and his face took on a pained and quizzical expression. As the train proceeded toward London, the American could stand it no longer. Arising from his seat, he approached the Britisher. "I say, Sir, did I or did I not hear you tell your host that his wife was the best bed companion you ever had?"

"Yes, you did," replied the Englishman. "She isn't really the best, but old Edward is such a jolly good fellow . . ."

Heredity, the little boy wrote, means that if your father didn't have any children and your grandfather didn't have any children, you won't have any children either.

Ben Franklin said, "It is hard to make an empty bag stand up." I'll bet he never had the job of getting a loaded bag into a taxi cab after a cocktail party.

Now that the tourist season is beginning, it's time for the country to close the roads and open the detours.

Three-fourths of the earth's surface is water and only one-fourth is land. It was the good Lord's intention that a man should spend three times as much time fishing as he does plowing.

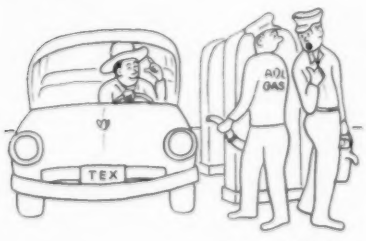
A young lady, beaming proudly, said to a man sitting next to her on the bus: "You probably wonder why I am so happy, but I have just been to the doctor, and after seven years of married life, he tells me I am about to become a mother."

"Well, how wonderful," replied the man. "I'm also happy today. You see, I'm a chicken raiser, and I have just developed a new strain with pink feathers and blue eyes."

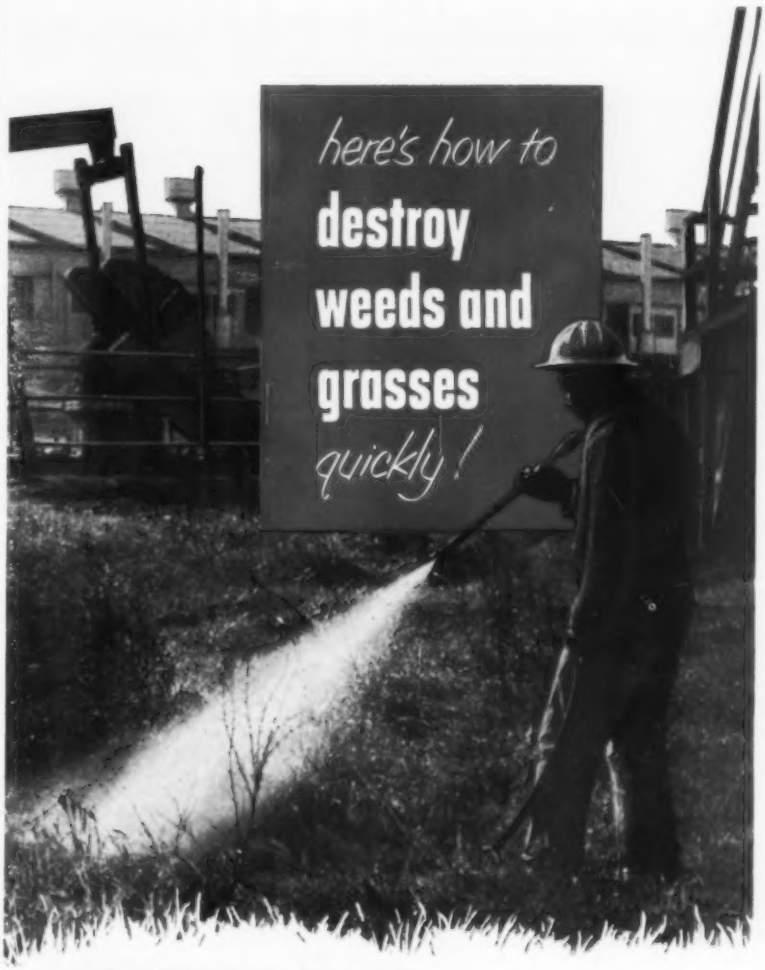
"How on earth did you ever do that?" the lady asked.

"I introduced some new stock," he replied.

"Well, confidentially," she whispered, "so did I."



"When he points to his hat he always means 10 gallons."



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Management Personals

D. T. Staples

G. F. Getty II

J. M. Houchin

David T. Staples was elected chairman of the board of directors of Tidewater Oil Company. Succeeding him as president is **George F. Getty II,** who advances from his previous post as vice president and general manager of the company's eastern division.

M. A. Wright, coordinator of worldwide producing activities, was elected to the board of directors of Standard Oil Company (New Jersey).

Leo D. Welch was elected to the executive committee, that acts for the board when the latter is not in session and is also available to the chief executive officer to assist in the discharge of executive duties. Welch and three other members of the committee were also named executive vice presidents. They are **Hines H. Baker, L. W. Elliott** and **E. E. Soubry.** All four, previously vice presidents, will serve with **Eugene Holman,** chairman, and **M. J. Rathbone,** president.

M. S. Beringer, retiring president, was re-elected chairman of the board and **E. D. Brockett,** formerly vice president, Gulf Oil Corporation, was made president and chief executive officer of The British American Oil Company Ltd. Other new appointments were **J. W. Morgan,** formerly general manager of B-A's manufacturing, as vice president, and **J. R. Yarnell,** formerly services manager, production department in Calgary and assistant secretary, as treasurer.

George Roberts Jr., manager of the research department, Pan American Petroleum Corporation of Tulsa was selected chairman of the Scientific and Technical Committee for the May 14-23, 1959, International Petroleum Exposition.

John M. Houchin, vice president and a director of Phillips Petroleum Company, was elected a member of the company's executive committee. He was elected to the board of directors in October 1957.

Dr. William E. Humphrey was appointed vice president in charge of petroleum exploration and **George Ware Knight** named vice president in charge of European activities, Pan American International Oil Company.

Wayne H. Walker is the new manager, administrative for Pan American International in New York. He will also be a director of the company.

George C. Merrick of Tulsa was named manager of industrial relations for Pan American International. He will also be in New York. Merrick was formerly employee relations supervisor for Pan American Petroleum Corporation in Tulsa.

Richard I. Galland was named president of American Petrofina Company of Texas, operating division of American Petrofina, Inc. He will have offices in Dallas, Texas, will also serve as vice president and general counsel of American Petrofina, Inc. **J. M. Shea Jr.,** and **Frank Durham,** were named vice presidents of American Petrofina Company of Texas. Other officers of the operating division are **D. R. Zachry Sr.,** executive vice president, and **Verne H. Maxwell,** vice president and general counsel.

L. L. Aitken, Denver, Colorado, oil executive, was elected executive vice president of Utah Southern Oil Company. He will be in direct charge of Utah Southern's exploration activities.

Two directors were elected. They are **Charles De Young Thieriot,** editor and publisher of the San Francisco Chronicle, and **Robert A. Podesta,** Chicago, general partner of Cruttenden, Podesta & Company, Bankers. Thieriot is also president of the Chronicle Publishing Company, which in addition to the newspaper, owns and operates KRON-TV in San Francisco. He is chairman of the board of directors of Bakersfield Broadcasting Company and a director of Castilla Corporation.

Directors re-elected include **Sheldon G. Cooper,** San Francisco; **George T. Hansen Jr.,** and **M. D. Paine,** both of Salt Lake City, and **J. E. Rouse,** Salt Lake City and Saratoga, Wyoming.

Rouse was re-elected president and Paine secretary. **Harry F. Suniville,** Salt Lake City, was re-elected treasurer and elected assistant secretary also.

K. W. Rugh

W. L. Phillips

H. D. Brookby

W. L. Phillips was appointed vice chairman of Phillips Petroleum Company's operating committee, and **H. D. Brookby** and **K. W. Rugh** were added to the committee's membership. Prior to his new appointment, Phillips was director of the new plants and joint enterprises division of the natural gasoline department. Brookby is manager of the company's foreign department and Rugh is manager of its advertising and public relations department.

E. A. Brown

L. G. James

C. M. Hill

T. S. Bacon

W. G. Wiegel

Louis G. James, vice president and comptroller, was elected to the new position of executive vice president (finance and accounting), Lone Star Gas Company. **E. A. Brown** was named executive vice president (operations). Brown was formerly vice president in charge of exploration and gas supply. **Willard G. Wiegel,** treasurer and director of personnel, was elected to the new position of vice president (personnel). He will continue also as treasurer. The new post of vice president (research and development), was given to **Thomas S. Bacon.** Prior to the election, Bacon was director of research and development. **Carl M. Hill** was elected vice president (exploration and gas supply), the post formerly filled by Brown. Hill has been serving as superintendent of operations in the exploration and gas supply division. **Howard J. Yonkers,** assistant comptroller, was elected comptroller to succeed James in that capacity.

The United Shareholders of America Award for outstanding management-shareholder relationship, was presented to **L. T. Potter,** Lone Star's chief executive, at the annual shareholders meeting. It is the third consecutive year the award has been received by Lone Star Gas Company and its wholly-owned subsidiary, Lone Star Producing Company.

Personals

▸ **R. E. Foss, H. O. Harder,** and **R. Paul Henry,** each a vice president, were named to the board of directors of Sunray Mid-Continent Oil Company.

Re-elected to the 15-member board were: **C. H. Wright, W. C. Whaley, R. W. McDowell, Paul E. Taliaferro, Jacob France, D. L. Frawley, Edward Howell, R. B. Parriott, E. M. Rouzer, A. A. Seeligson, Glenn J. Smith,** and **Jay P. Walker.**

▸ **Carl M. Deckard,** controller of the Oasis Oil Company of Libya, located in Tripoli, a wholly-owned subsidiary of the Ohio Oil Company, was appointed general auditor in the auditing division of Ohio Oil. **Lewis J. Qualkenbush,** assistant supervisor of the production accounting department, will replace Deckard in Tripoli.

▸ **Archie D. Gray,** formerly vice president and general counsel was designated a senior vice president of Gulf Oil Corporation. **Joseph E. Bounds** was elected administrative vice president, tax department, **I. G. Davis** elected administrative vice president, production, and **B. R. Dorsey,** administrative vice president, manufacturing.

A. Dunys Cadman was named executive representative, New York City, for Gulf Oil. Since 1952, he has been industrial relations manager of The British American Oil Company Limited, Toronto, Canada.

▸ **Robert B. Acker** was appointed corporate secretary of International Petroleum Company, Ltd. He succeeds **Donald Henry** who has resigned to accept a position with Jersey Standard in New York. Acker will be located in the executive offices, Coral Gables, Florida.

DEATHS

▸ **John L. Martin,** 32, supervising engineer, well logging, for Atlantic Oil Company's research and development department, died March 22 of a heart attack.

▸ **Preston G. Northrup,** 62, oil man who handled leases during the early days of West Texas oil discoveries, died at his home in San Antonio, Texas, April 12.

▸ **Ernest N. Smith,** 77, formerly eastern division manager for the National Supply Company, died April 29, at Clearwater, Florida.

▸ **Peter J. Varini,** 36, a senior geologist for Sun Oil Company at Dallas, died suddenly the afternoon of April 5 following a heart attack suffered at his home in Richardson, Texas.

▸ **George Vincent Slottman,** 54, vice president-research and engineering of Air Reduction Company, Inc., died April 21 after a brief illness.

▸ **Clyde H. Britten,** vice president in charge of manufacturing and a director of The Lubrizol Corporation, died of a heart attack on April 5 at the age of 53.

▸ **J. P. Ratigan,** 86, one of California's pioneer oil well equipment manufacturers, died April 18 after a short illness.

▸ **John S. Patchin,** 65, retired assistant plant manager of the Philadelphia refinery of The Atlantic Refining Company, died April 29 at his home in Haverton, Pennsylvania.

▸ **Fred Champion,** former treasurer and assistant secretary of Southern Counties Gas Company, and an employee of the utility for 27 years until his retirement April 1940, died April 21. He was 83 years old, and had been suffering from leukemia for several years.

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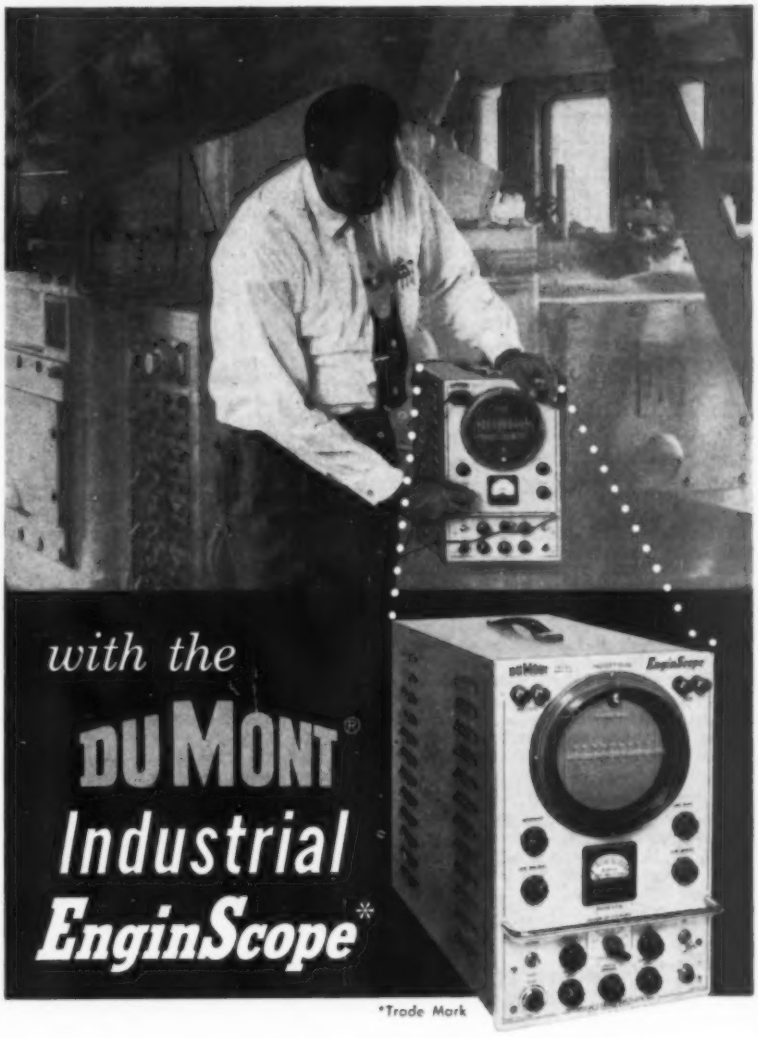

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Automotive Equipment Division

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• News
• People

The Trade PARADE

A NEW DIVISION was formed by Mid-Continent Supply Company along the Gulf Coast, President Ken W. Davis has announced. J. A. Daugherty, Mid-Continent vice president at Houston, will supervise both new divisions. The Houston Division remains under division manager, R. S. Weilman, and now includes the Beaumont territory, Houston, Refugio, Falfurrias, Corpus Christi and San Antonio.

The new South Louisiana Division is under the supervision of division manager, W. M. Day, at New Orleans. Day formerly was division sales manager at New Orleans. The new division includes Orange, Texas, and Lake Charles, New Iberia, Houma, Morgan City, Harvey and Delta Tank branches at Lafayette and Westwego, Louisiana.

Assistant division manager in charge of stores at New Orleans is J. O. Ramsey, former district manager there.

NEW PRESIDENT of the American Welding Society is Gustav O. Hoglund, head of the Welding Section of the Aluminum Company of America Process Development Laboratory.

The new president will take office June 1 and during the 1958-1959 fiscal year will direct the Society's many activities devoted to advancing the art and science of welding.

Mr. Hoglund has made many noteworthy contributions to the welding industry. He is the holder of several patents and is responsible for many developments in the techniques of resistance and arc welding of aluminum and aluminum alloys.

A $2,500,000 BUILDING, which will soon house the law and business administration school of Duquesne University, Pittsburgh, has been named "Rockwell Hall" in honor of Col. Willard F. Rockwell. The 10-story building — largest on the entire campus — is expected to be completed this year.

Col. Rockwell, board chairman of Rockwell Manufacturing Company and Rockwell Spring and Axle Company, has been chairman of the President's Advisory Board at Duquesne since 1952.

FREDERICK M. MAYER, president of Continental-Emsco Company, Dallas, was elected a director of the Youngstown Sheet and Tube Company. Continental - Emsco Company is a division of the Youngstown Sheet and Tube Company and Mayer was elected vice president of the parent organization in December 1956, when Continental Supply Company and Emsco Manufacturing Company were merged.

F. M. Mayer

Mayer has been a director and past president of the Petroleum Equipment Suppliers Association, director of the Mid-Continent Oil and Gas Association, and past director of API.

RIGHTS TO MANUFACTURE unplasticized polyvinyl chloride products by a special process have been granted BTR Industries, Ltd., London, by Tube Turns Plastics, Inc., Louisville, Kentucky.

Carl B. McLaughlin, executive vice president of Tube Turns Plastics, and Dr. W. D. Scott, director of BTR Industries, announced that a license agreement provides for rights to the Hendry injection molding process, furnishing of presses and technical counsel.

BTR Industries, Ltd., has 10 factories in Great Britain, is a major manufacturer of plastic and rubber products and engages extensively in international trade. Tube Turns Plastics, Inc., an affiliate of National Cylinder Gas Company and Jackson & Church Company, manufactures injection molded unplasticized polyvinyl chloride fittings and valves for industrial and commercial piping systems. TTP also makes custom products by injection molding.

THREE NEW WAREHOUSE facilities and a replacement were constructed in various parts of the oil country by Larkin Packer Company.

New installations are at Farmington, New Mexico, Harvey, Louisiana, and Pampa, Texas. The replacement is at Odessa, Texas.

Odessa installation will serve West Texas and part of New Mexico. Store manager there is T. H. Lampe. Farmington will supply oil industry needs for the Four Corners area. Store manager is Sanford Newman.

The Pampa unit services Western Kansas and the Panhandle. Store manager is W. B. Cotton. At Harvey, under the store management of Sam Gibbs, South Louisiana is served.

TALLEST AND NEWEST landmark in West Allis is Allis-Chalmers modern seven-story West office building located directly across the street from the firm's main office.

The new building comprises 110,000 sq ft of floor space, has a facade of glazed blue brick, glass, and aluminum striping and provides office space for more than 800 employees.

Flexibility of use was an important factor in the design of the building. Departments can be arranged in various combinations and the interior was laid out with special emphasis on the efficient handling of office work.

NEW INDUSTRIAL VALVE distribution district was formed by Ohio Injector Company for the southwest and Gulf states area with headquarters at Tulsa. E. G. Blaylock, Tulsa industrial engineer, has been named manager for the division, which extends from Kansas to the Gulf states.

EXCLUSIVE DISTRIBUTOR for the Harold Brown Company's line of production equipment is Shaffer Tool Works, with headquarters in Brea, California. Shaffer's territory will cover California, Wyoming, North Dakota, and Colorado. The line includes gas lift valves, surface controllers, and oil and gas well plungers.

Presidents I. Melville Stein of Leeds & Northrup and James M. Skinner, Jr. of Philco examine a scale model of the new transistorized digital computer.

A SHARED COST PROGRAM was launched by Philco Corporation and Leeds & Northrup Company to develop, design and build a digital computer which will have important applications in industrial process control and in scientific and engineering computation, including data processing.

Development work already is under way, with field trials of a prototype computer system anticipated during 1959.

Presidents James M. Skinner, Jr., of Philco and I. Melville Stein of L&N, pointed out that "the significance of this relationship between Leeds & Northrup and Philco is that, for the first time, the broad knowledge, experience and understanding of L&N in the process control field is being combined with Philco's knowledge of transistorized digital computers to create a new control system, the core of which will be a digital computer specifically designed to meet the rigid requirements of industrial process control."

PURCHASE OF CONKEY equipment, patents, applications, drawings, patterns and records from Henry Hunter and George Dickey of New York was announced by Chicago Bridge & Iron Company.

Evaporator, crystallizer and filter equipment previously sold by the CB&I Conkey Division, which has now been integrated with CB&I operations, will be designated hereafter as Chicago Bridge & Iron Company evaporators, crystallizers and filters.

J. PAT BEAIRD, president of the J. B. Beaird Company, Inc., Shreveport, La., has been elected a director of American Machine & Foundry Company of which his firm is a subsidiary. Beaird is a major manufacturer of LP (liquefied petroleum) gas systems and packaged compressor plants.

J. P. Beaird

Beaird presently is on an extended inspection and market survey trip to Venezuela. The company has become increasingly active in foreign markets.

Trade Parade

DEDICATION of the new Freedlander Research and Development Laboratories at Hawthorne, California, marks the latest of a series of expansions by The Dayton Rubber Company in plastic foams, adhesives and foam rubber fields.

"This new laboratory will provide industry with the most complete facilities erected by a product manufacturer for basic research and product development of the new miracle urethanes," said C. M. Christie, president of both American Latex and Dayton Rubber.

The research center was named after A. L. Freedlander, chairman of the board of Dayton Rubber. Freedlander, who had been president of Dayton Rubber from 1936 to 1957, is an authority and pioneer researcher in the development of synthetic rubber.

OILFIELD TANK MANUFACTURERS Association elected Henry A. Ruysser, Jr., executive vice president of Black, Sivalls & Bryson, Inc., president, at a recent meeting in McAllen, Texas, according to E. H. Zachariae, secretary.

E. M. Burt, president of Burcamp Steel Company, was elected vice president and J. E. Fogarty, vice president of Graver Tank and Manufacturing Company was elected treasurer. Newly elected members of the executive committee, who will serve with Ruysser, Burt and Fogarty, are: G. O. Marchant, president of Continental Tank Company; Tyson Smith, president of Tyson Smith Company; Charles Sivalls, president of Sivalls Tanks, Inc.; and C. D. Haehl, Jr., general manager, Production Equipment Division, Parkersburg Rig and Reel Company.

L. F. SHOEMAKER, Allis-Chalmers Manufacturing Company, was elected president of the Internal Combustion Engine Insitute at the annual meeting in March. He succeeds F. C. Langston, Jr., of the P & H Diesel Engine Division, Harnischfeger Corp., who continues as a director.

L. F. Shoemaker

Other officers of the Institute for 1958 include Commander A. D. Marks, Hercules Motors Corp., vice president; H. H. Howard, Caterpillar Tractor Co., treasurer; and James V. Doe, Willys Motors, Inc., secretary.

AN EASTERN DIVISION service branch was opened by McCullough Tool Company at Ozark, Arkansas. Charles Lee Cavanaugh, formerly service unit operator at McCullough's Magnolia, Arkansas service branch, has been appointed branch manager and is in charge of operations at the new Ozark branch office.

ATLAS PIPE INC. has bought Universal Inspection and Services Company, forging another link in the Atlas chain of companies designed to offer complete tubular goods service to the oil industry. Through Universal Inspection and Service Company, which operates electronic and optical devices for inspection and testing of oil country tubular goods, Atlas is equipped to inspect and test tubing, casing and drill pipe in the Gulf Coast oil fields as well as in the mills and shops where they are processed.

CAMERON IRON WORKS, INC., entertained several thousand members of the oil drilling and producing industry at the "Big Blowout" opening of their new Odessa, Texas, plant. The company introduced and demonstrated several new products to acquaint the industry with services available at the 15,000 sq ft plant, warehouse and office building. Highlights of the opening included showing Cameron's new, small lightweight high pressure blowout preventer — the first 7-in. 15,000 psi working pressure preventer made — and a new gate valve.

AN ARRANGEMENT whereby Wilson Supply Company will distribute the complete line of "Oilwell" drilling equipment and the Witte line of oil field engines in the domestic territory served by its 20 branch stores and nine district sales offices was announced jointly today by Fred F. Murray, president of the Oil Well Supply Division of United States Steel, and Wallace D. Wilson, president of Wilson Supply Company.

The arrangement makes an extension of U. S. Steel oil field products which Wilson Supply has marketed for many years. The company has distributed "Oilwell's" Wilson-Snyder oil country products for the past 31 years.

A PRICE INCREASE in the products of four departments of the turbine division was announced by General Electric.

The price increase will be 3 percent. W. S. Ginn, vice president and general manager of the turbine division, stated that the increases are a result of an adjustment to partially meet rising materials and production costs.

UNIQUE PORTABLE STORE of National Supply at Estevan, Saskatchewan, Canada, has been replaced by a permanent structure. Of masonry and metal construction, with a modern store front, the new building includes a sales room, warehouse, pump shop, and office. Kenneth S. Barr is store manager. The store is under the supervision of James H. Linstead, district manager of the Saskatchewan-Manitoba District.

Worthington Corporation. John V. Jirasek was appointed manager of the newly created Process Industries department, with headquarters in the Harrison, N. J. Marketing division. He formerly served as sales manager of the Worthington Southwestern regional sales organization. In his new post, he will be responsible for strengthening the corporation's relations with their customers in the petroleum, petro-chemical and associated industries.

Oil Metering and Processing Equipment Corporation. Jimmy L. Wyche was made sales engineer for the Rocky Mountain area. He will be located in Casper, Wyoming.

Prior to joining Oil Metering, Wyche worked as a sales engineer for Black, Sivalls & Bryson, Inc. in the Rocky Mountain area. He was most recently employed by International Gas Lift of Talara, Peru, South America.

WELEX, INC. OPENED a new district operating office at 2924 North Avenue, Grand Junction, Colorado. P. E. Ganus, manager of the Grand Junction district, moved to this area from Cortez. He has been in oil field service work with Welex for 5 years — working most of the time in the Rocky Mountain area.

UNDER A NEW LICENSE, Milton Roy Company will have exclusive rights for production of Oliver Diaphragm Slurry (ODS) pumps in sizes to approximately two gallons per minute. Milton Roy Company will manufacture small designs for accurate proportioning applications in the U. S. The Philadelphia plant will be used.

COMMUNICATION PRODUCTS Department of General Electric has established district sales offices in 11 new cities as part of an expansion of its field organization for the sale of mobile radio equipment.

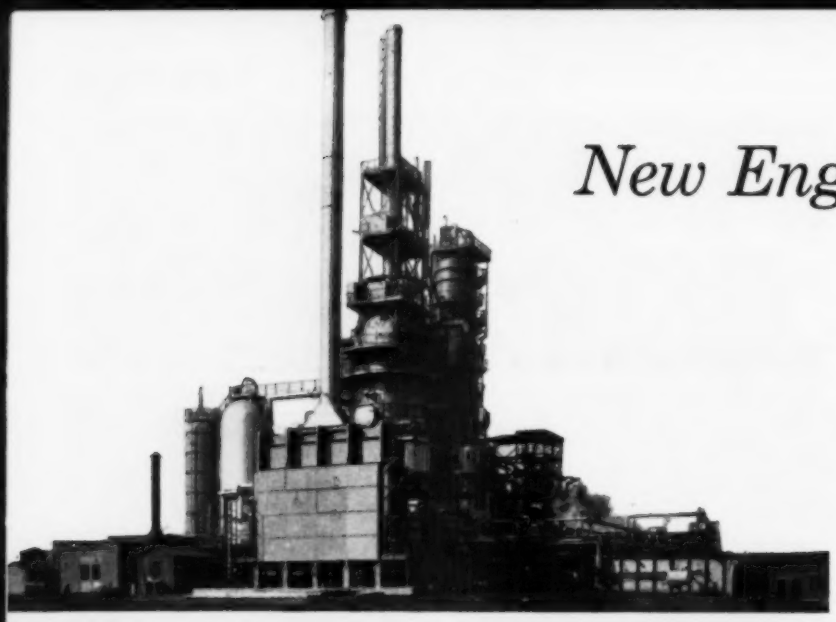
New communities where G-E offices are located and managers in charge are: Tampa, Florida, W. S. Watson; Pompano Beach, Florida, F. W. Hall; Fort Wayne, Indiana, A. C. Shepard; Memphis, Tennessee, L. K. Elrod; Appleton, Wisconsin, G. W. Hopkins; Bismarck, North Dakota, V. F. Anderson; San Rafael, California, F. I. Deetkin; Spokane, Washington, D. N. Corbin; Charleston, West Virginia, H. L. Johnson; Birmingham, Alabama, A. W. Plan; Richmond, Virginia, F. Christopherson.

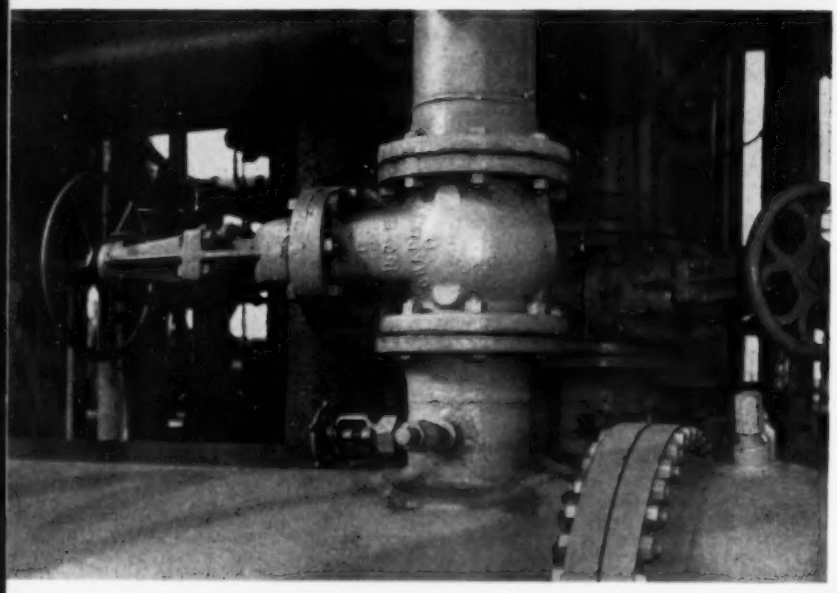
CLOSING OF DAWSON CREEK, B. C., store of U. S. Steel's Oil Well Supply Division and transfer of all personnel and inventory to Fort St. John, B. C., where a new "Oilwell" branch has opened, was announced by W. A. Weir, Canadian area manager of the division. The Fort St. John store will serve the territory formerly served by the Dawson Creek store.

Joseph G. Walsh, manager of the new store, was store manager at the "Oilwell" Dawson Creek branch. Field representatives of the new store are Gordon R. Hill and Douglas A. Ozey.

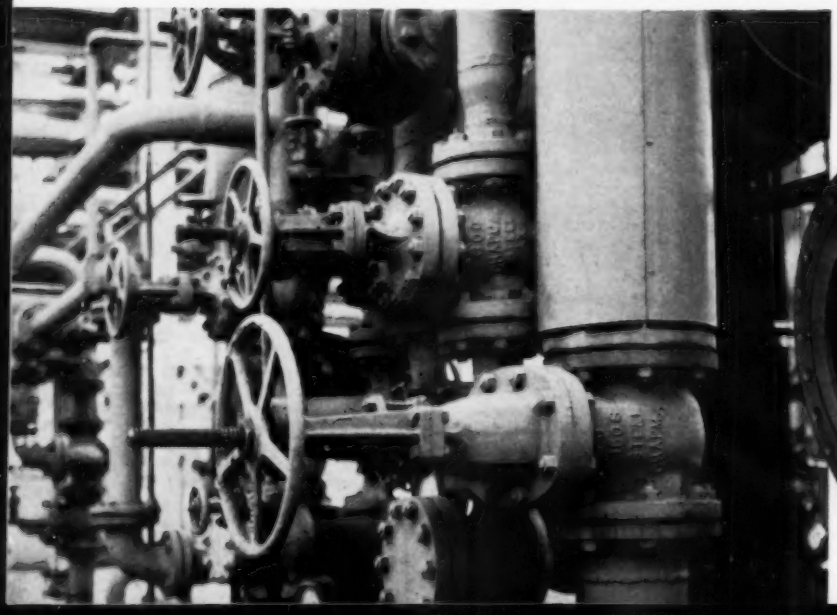
J. I. Case Company. Promotion of Don A. Beckenbaugh to the newly created position of sales and manufacturing administrator has just been announced by Marc B. Rojtman, president, Beckenbaugh now reports directly to Rojtman and has full responsibility over the coordination of the sales and production requirements of the company.

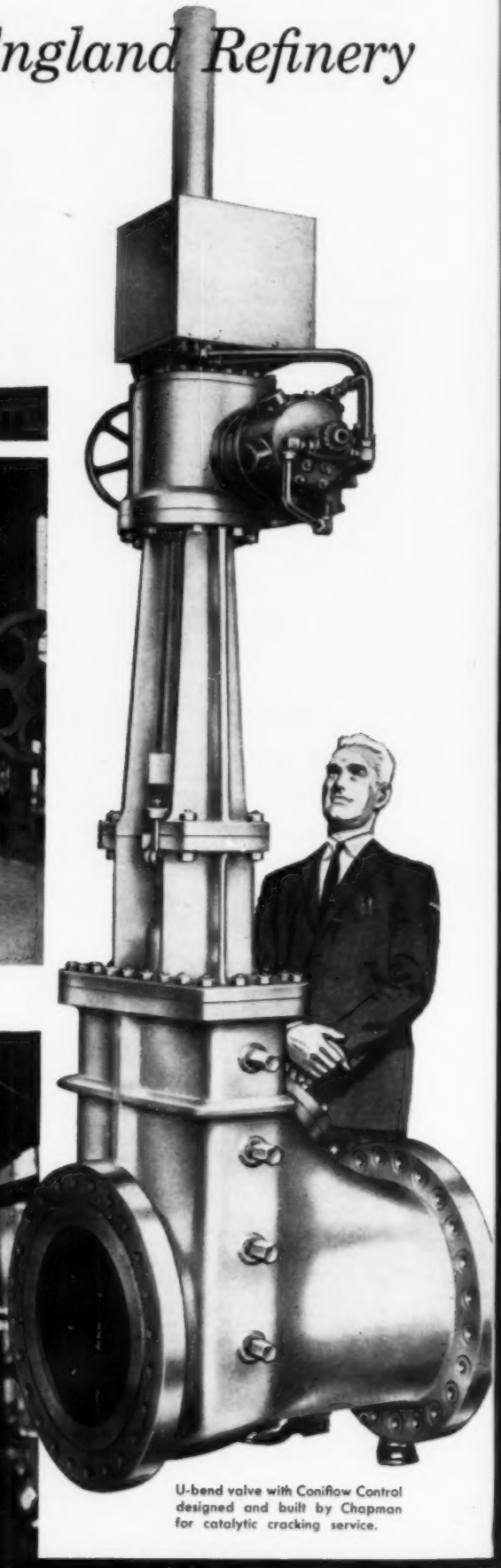
New England Refinery





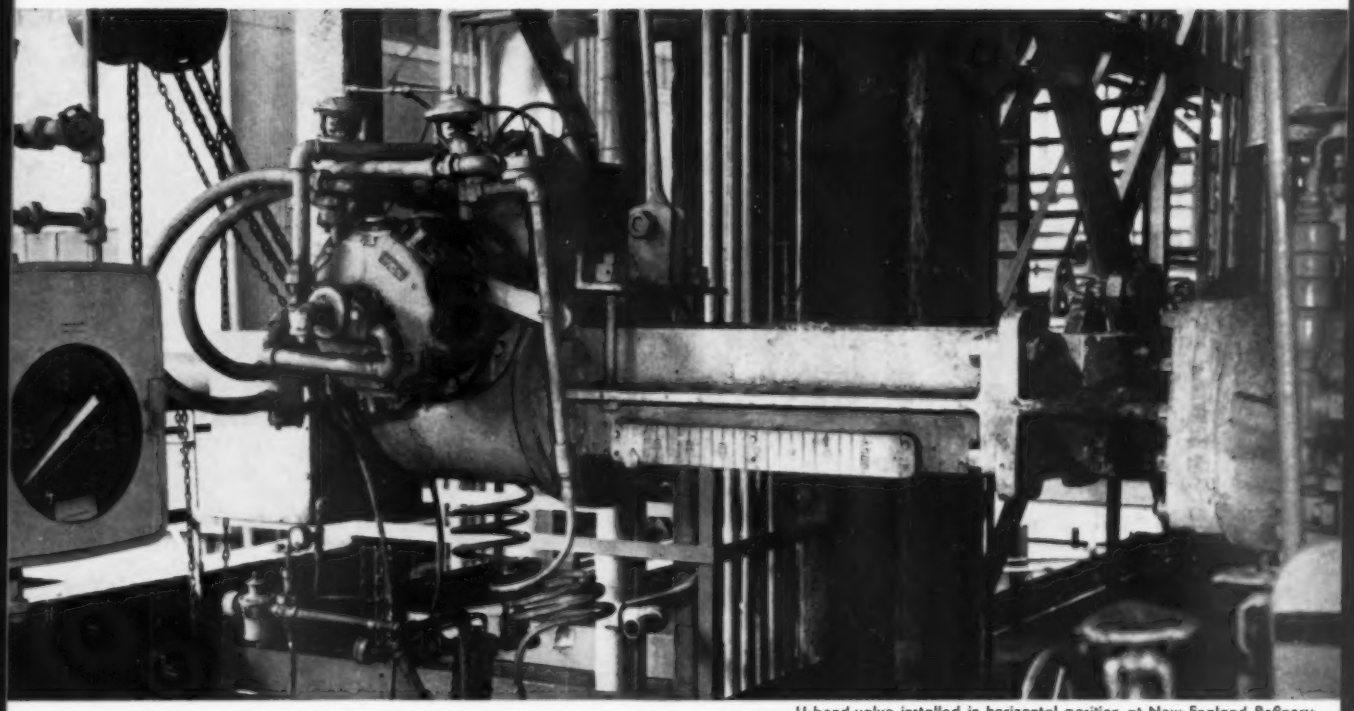
Above and below, some of many Chapman Valves giving service at New England Refinery at Everett.





U-bend valve with Coniflow Control designed and built by Chapman for catalytic cracking service.

uses CHAPMAN VALVES



U-bend valve installed in horizontal position at New England Refinery.

This isn't just a regional story. Far from it. In addition to the New England Refinery in Everett, Massachusetts, the Esso Standard Oil Company has other refineries at Linden, New Jersey; Bayonne, New Jersey; Baltimore, Maryland; Baton Rouge, Louisiana and Charleston, South Carolina.

These, like other leading refineries in all parts of the world, use Chapman Valves . . . both standard and special . . . *for good reasons.*

Chapman has all the engineering and manufacturing facilities to think out and work out valves that will fully meet the requirements of today and, just as important, to meet tomorrow's requirements.

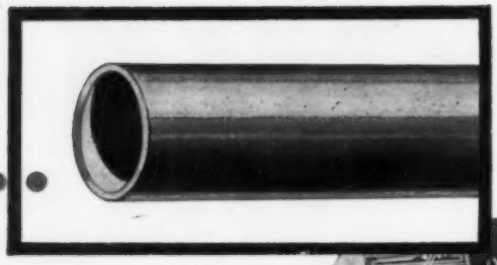
Esso's New England Refinery is a good example of meeting these requirements. When World War II brought on an urgent demand for better and cheaper gasoline and fuel, a new method . . . catalytic cracking . . . was developed. Today, with this added miraculous giant known as a "cat cracker," built by Foster Wheeler, the New England Refinery is a still more modern plant. Tanks with a total capacity of 60,000,000 gallons can be filled with finished products. Some of this production is delivered to all of New England and to parts of New York State to meet industrial, automotive and domestic needs . . . a real, important service.

The CHAPMAN *Valve Manufacturing Co.*

INDIAN ORCHARD, MASSACHUSETTS

It pays to talk about your valve requirements for today and tomorrow with Chapman. The Chapman Valve Manufacturing Company has the men, the brains and the facilities to meet these requirements fully, no matter how tough they are. Chapman has the engineers, metallurgists, experience, and manufacturing capacity to produce the valves you need. Write, and we'll gladly consult with you.

Casing...



Clutches...

Complete Supply

from Mid-Continent where and when you need them . . . .

Complete in-the-field stocks of parts and equipment at your Mid-Continent field store are planned in advance to anticipate the specific supply requirements of your area.

For around-the-clock supply service from thousands of items carried in stock, call your local Mid-Continent representative.

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Don't pay today's prices for yesterday's engines!

Read on following pages how the new Worthington SLHC engine compressor can substantially reduce your gas handling costs

Only SLHC Turbocharged Gas-Worthington offers all these

MODERN DESIGN

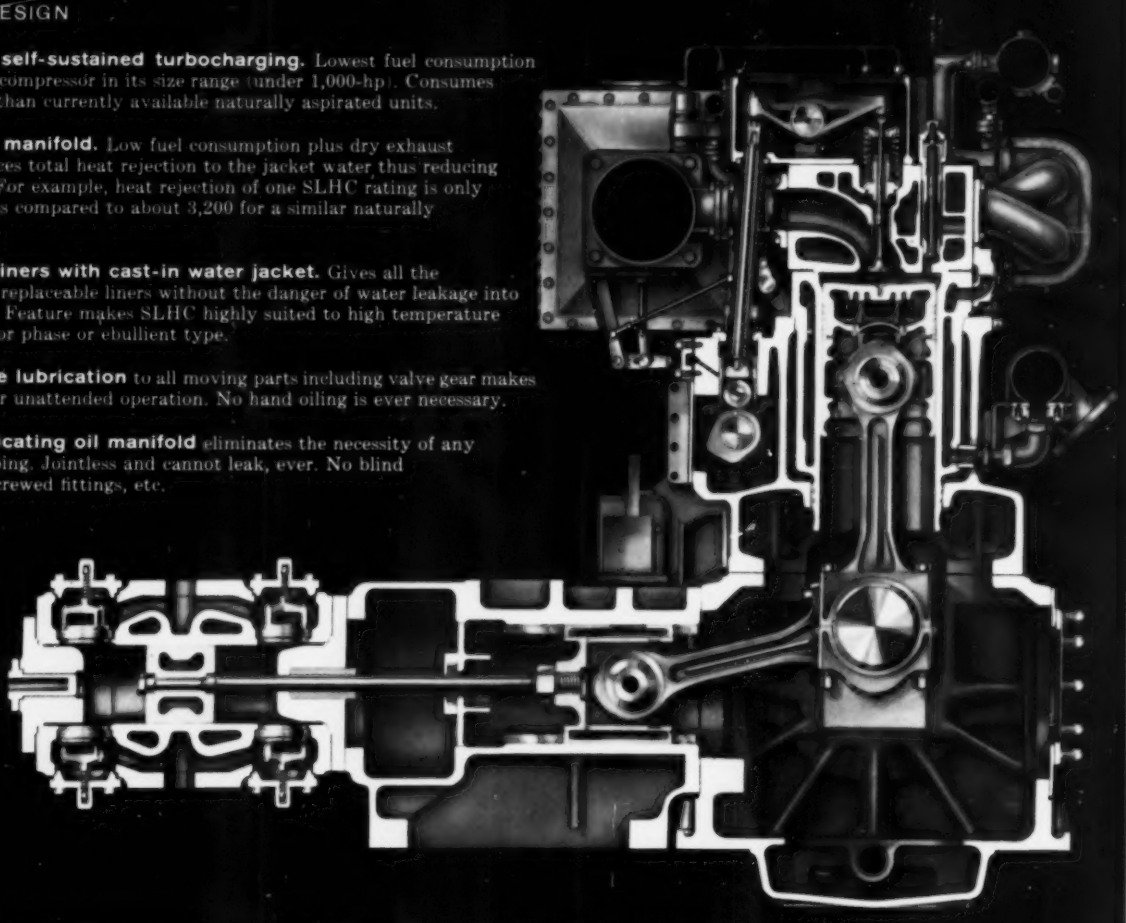
Completely self-sustained turbocharging. Lowest fuel consumption of any engine compressor in its size range (under 1,000-hp). Consumes 20% less fuel than currently available naturally aspirated units.

Dry exhaust manifold. Low fuel consumption plus dry exhaust manifold reduces total heat rejection to the jacket water, thus reducing radiator size. For example, heat rejection of one SLHC rating is only 2,015 BTU's as compared to about 3,200 for a similar naturally aspirated unit.

Removable liners with cast-in water jacket. Gives all the advantages of replaceable liners without the danger of water leakage into the crankcase. Feature makes SLHC highly suited to high temperature cooling of vapor phase or ebullient type.

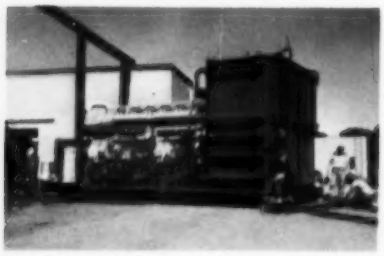
Full pressure lubrication to all moving parts including valve gear makes SLHC ideal for unattended operation. No hand oiling is ever necessary.

Cast-in lubricating oil manifold eliminates the necessity of any internal plumbing. Jointless and cannot leak, ever. No blind connections, screwed fittings, etc.



Six-cylinder SLHC unit installed by Northern Natural Gas Co. in the Oklahoma Panhandle.

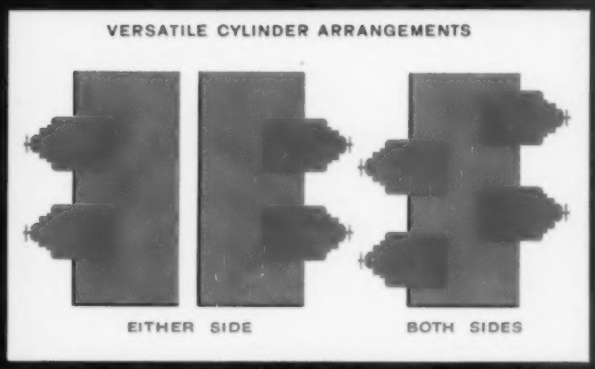
One of three 6-cylinder skid-packaged SLHC units being prepared for shipment to Bolivia, S. A.



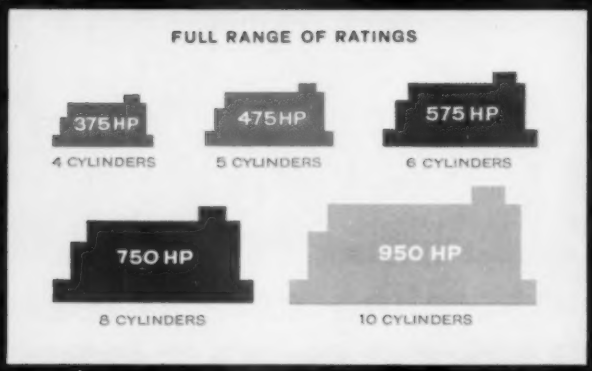
Six-cylinder skid-packaged SLHC unit for service in a Louisiana gas field.

Engine Compressor by modern, dollar-saving features

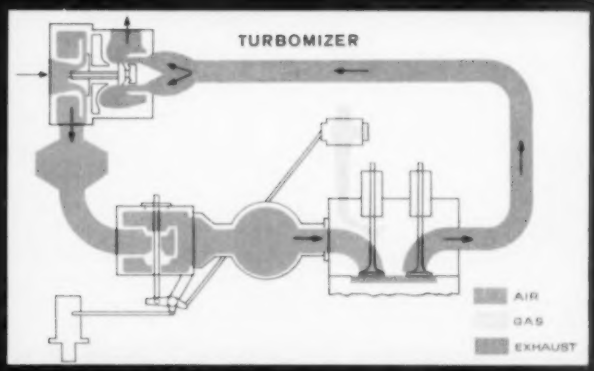
The SLHC will give you about 20% better fuel economy than currently available naturally aspirated units. This chart shows the savings per year for each 1000 hp of continuous operation on natural gas.



Piping and construction problems can be greatly simplified thanks to versatility of cylinder arrangements on SLHC. Cylinders can be mounted on either or both sides. If mounted on both sides, SLHC permits twice as many cylinders as most engine compressors in its size range.



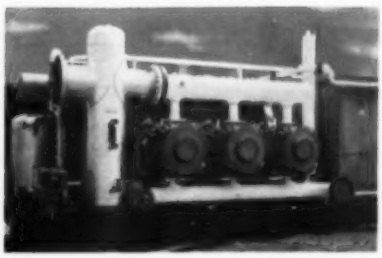
These are the range of ratings offered in the SLHC. Note that all units operate at the conservative speed of 450 rpm with a conservative bmep of under 135 psi. All units may be skid "packaged" —including the 950 hp rating, the largest available for this type service.



Worthington's Turbomizer is the simplest fuel control system on the market. It offers remarkably favorable fuel consumption and stable operation over the complete load and speed range. Allows operator to compensate for different fuels and heating values in one adjustment.

One of two 4-cylinder SLHC engine compressors to be installed by Permian Basin Pipeline Co. in Lea County, N. M.

Six-cylinder skid-packaged SLHC gas-engine compressor for a Texas natural gasoline pant.



For complete details, get in touch with your nearest Worthington district office. Or write to Worthington Corporation, Section 43-1, Harrison, N. J. In Canada: Worthington Canada Ltd., Brantford, Ont.

WORTHINGTON

User-survey shows – in all operating categories

FEATHER VALVE VOTED BEST

Simplest Construction:

FEATHER VALVE

VALVE A

VALVE B

Lowest Maintenance:

FEATHER VALVE

VALVE A

VALVE B

Most Efficient:

FEATHER VALVE

VALVE A

VALVE B

Quietest:

FEATHER VALVE

VALVE A

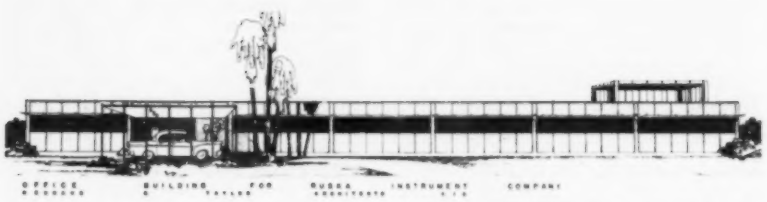
VALVE B

A recent survey among compressor users showed this marked preference in all four operating categories for the amazing Feather* Valve. The Worthington Feather Valve is the lightest, fastest-acting compressor valve available. Because of its lightness and flexibility it provides very sharp action with virtually no slip or back-flow. And because it works with no impact . . . has no buffer plates or cushioning devices . . . it is all but indestructible, assures long-life with negligible maintenance costs.

To get the most in performance when you buy your next compressor, specify Worthington with the rugged Feather Valve feature. Worthington Corporation, Harrison, N. J.

*REG. U.S. PAT. OFF.

WORTHINGTON



TO KEEP PACE with its expanding world-wide market for specialized instruments for the oil industry and geomagnetic instruments, Ruska Instruments has announced construction will start immediately on a combination office, laboratory and manufacturing structure in Houston.

Officers of the company are Walter Ruska, president; C. D. Varner and S. H. Buckley, vice presidents, and M. M. Lignoul, secretary-treasurer.

Ruska pioneered production of specialized instruments for the oil industry, and in particular, laboratory installations for the determination of the physical properties of oil field cores and petroleum fluids.

▸ **Welex of Canada, Ltd.** Expanded facilities and services announced by Bruce A. Redwine, vice president and general manager included the following positions: Stan Nelner, vice president and manager of operations; H. T. Harvey, Eastern division manager; H. J. Fairbanks, Western division manager. Eastern division has headquarters in Regina and operation districts in Estevan and Sarnia. Western division is headquartered in Edmonton with operation locations in Edmonton, Drayton Valley, White Court, Red Deer, Calgary and Wainwright.

▸ **Wilson Supply Company.** Announced was appointment of Fred Sexton as manager of the new store at Monahans, Texas. Sexton goes to Monahans from Hobbs, New Mexico, where he has been a field salesman.

Homer Doughty, Jr., formerly a field salesman out of the Wilson store at Victoria, Texas, has been transferred to the Midland, Texas, sales office of the company.

▸ **Walworth Company.** G. A. Hoffman was appointed assistant vice president, Metropolitan division. He is manager of the Metropolitan sales division, which includes an area of 50 mile radius of New York City, with headquarters in Harrison, New Jersey.

Theron D. Hyatt was promoted to treasurer of the company. He has been assistant treasurer since 1955.

▸ **Petrolite Corporation.** Tretolite Company of California Division. W. Wallace Anderson has been named plant manager at Los Angeles, by L. T. Monson, general manager of that division. He succeeds C. N. Stehr, who is now on special assignment for Petrolite Corporation.

▸ **Air Preheater Corporation.** H. S. Marshall was made executive vice president and W. E. Hammond and T. R. Halstead vice presidents. Hilmer Karlsson has been appointed assistant to the president and consulting engineer. The company makes heat transfer equipment.

▸ **Cooper-Bessemer.** Frank L. Friedli was promoted to assistant sales manager, special projects. He will be directly responsible for the sales of automatic controls to the oil, gas, chemical and power industries.

Robert L. Kietzman was named sales engineer for the St. Louis branch office. Working under the direction of F. J. Hunter, branch manager, Kietzman will be responsible for engineering and sales contacts with users of compressors and engines in the Missouri and Southern Illinois areas.

James R. Craine is the new branch manager, East Central District, Mount Vernon, Ohio. He is responsible for all applications and sales of engines and compressors in the East Central area.

Donald T. Koch is new sales engineer at East Central district office. He will work under the direction of Craine.

James H. Caldwell was appointed district service manager, Pacific Coast. He will be responsible for the supervision of all Cooper-Bessemer service activities in the Los Angeles, Seattle, San Francisco, and Casper areas.

Ralph L. Reynolds was made branch manager, Grove City, Pennsylvania, sales office. He fills the position formerly held by Fred W. Green, retired.

▸ **Texas Instruments.** Eugene McDermott, a co-founder of the company and chairman of the board since 1948, announced election of new officers. The board elected a new chairman, J. E. Jonsson, and a new president, Patrick E. Haggerty. McDermott continues as an officer and director and was elected chairman of the executive committee.

Richard A. Arnett was named marketing manager of the Industrial Instrumentation division announced E. O. Vetter, division general manager.

▸ **Continental-Emsco Company.** Charles Spitzfaden, Jr., was appointed drilling equipment sales engineer. He will headquarter in the oil field equipment and supply company's home office in Dallas.

▸ **Chicago Bridge & Iron Company.** Thomas R. Tucker, Jr., formerly of Birmingham Erection district, has been transferred to the company's Atlanta sales office.

▸ **Allis-Chalmers Manufacturing Company.** T. L. Mellish is appointed manager, parts sales, for the construction machinery division. He has been assistant manager since February 1956.

John Cresto is appointed manager, parts sales, for the engine-material handling division. He has been parts sales representative at the Milwaukee home offices since 1956.

▸ **Aeroquip Corporation.** Ted Mosher was named industrial sales manager. His duties will include responsibility for the division's industrial distributor, OEM, and marine sales in the territory west of the Rocky Mountains.

▸ **Fram Corporation.** Appointment of James H. Carmine, formerly president of Philco Corporation, as special consultant in sales, advertising, merchandising and marketing was announced by Steven B. Wilson, chairman of the board.

▸ **Baash-Ross Division** of Joy Manufacturing Company. B. J. Terrell was named chief engineer for Baash-Ross Division. He will be located at the Houston headquarters in charge of the engineering departments of the Houston and Long Beach plants, and will supervise product design, and the new product research and development program.

E. R. (Lindy) Lindgren has been appointed Baash-Ross Division West Coast operations manager with offices in Long Beach, California.

▸ **American Cyanamid Company.** R. E. Leach was appointed assistant manager for the Willow Island and Marietta, Ohio, plants of the Organic Chemicals Division.

W. A. Weber has been named manager of plant services and Stuart Whitehead manager of the rubber chemicals manufacturing department of the Bound Brook plant, New Jersey, Organic Chemicals Division.

▸ **Lone Star Steel Company.** Phil Clarke has been named manager of hot roll steel products. He joins Lone Star Steel after 8 years in steel sales with Youngstown Sheet and Tube Company.

▸ **Lunkenheimer Company.** Richard G. Brown was made director of industrial relations. Brown, with 17 years' experience in the industrial relations field, succeeds Jost A. Braam, who is retiring after 49 years of service.

▸ **ALCO Products, Inc.** Perry T. Egbert was elected chairman and William S. Morris as president. Egbert has been president of the company and Morris executive vice president. Both had held their former offices since December 1, 1952. They are career ALCO executives.

PIPE—All Your Needs

For the fastest service on *ANY* pipe order—especially for the unusual or hard-to-get sizes . . . make just one call to your nearest Foster office. Tested and structural stocks, ⅛" to 48", all walls and all specs for every purpose. Also valves and fittings from warehouse stocks. Send for free catalogs and ordering guides. PT 6

Complete Contractor Service—Since 1901

L. B. FOSTER CO.

PITTSBURGH 30 • ATLANTA 8 • NEW YORK 7
CHICAGO 4 • HOUSTON 2 • LOS ANGELES 5

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Trade Parade

Stratoflex, Inc. New officers of the company which headquarters at Fort Worth, are: K. W. Davis, president and general manager; D. H. Thornbury, vice president; C. A. Thomas, vice president-sales; John Tullis, vice president-manufacturing; R. O. Moore, chief auditor; W. E. Strittmatter, secretary-treasurer; Byron Scarborough, assistant secretary; B. L. Coontz, assistant secretary; W. B. Hague, assistant treasurer.

Jones & Laughlin Supply Division. Two major appointments in the sales organization were made, according to W. L. Wolfe, vice president — sales. A. G. Wehrley was promoted to district sales manager of East Texas district with headquarters at Longview, Texas; V. H. Weldon, Jr., was promoted to manager of the Canadian region with headquarters at Calgary, Alberta.

J. E. Shaver was appointed store manager at Alice, Texas. He was formerly assigned as salesman at Tulsa, Oklahoma.

New store manager at Midland, Texas, is D. W. Speck. He was previously assigned as salesman at Hobbs, New Mexico.

Haney Atyia, salesman at Ballinger, Texas, has been assigned as salesman at Midland, Texas. John W. Payne, salesman at Lindsay, Oklahoma, has been assigned as salesman to Hobbs, N.M.

G. R. Kennedy, formerly store manager at Chase, Kansas, is appointed store manager at Casper, Wyoming, and W. J. Doerfler, formerly storeman at Chase is appointed store manager at that store. C. E. Sample, formerly store manager at Casper, Wyoming, was appointed salesman for Wichita Falls, Texas, and S. D. Martin, salesman at Estevan, Saskatchewan, Canada, is transferred to Calgary, Alberta, Canada. L. B. Rainey Jr. was appointed assistant manager — project sales department and M. L. Eubank, district sales manager, has retired after 30 years of continuous service. A. G. Wehrley, formerly assistant district sales manager at Longview, replaces Eubank.

M. W. Kellogg Company. H. P. Wickham was named manager of a newly formed project engineering department. The department combines the operating division with project engineering. Wickham was formerly manager of operating division, process department.

Bucyrus-Erie Company. Jerry D. Finley was appointed water and oil well drill sales representative for the Evansville (Ind.) territory, which includes Indiana, Kentucky, Ohio and West Virginia, the province of Ontario and parts of nearby states.

Barrett Division, Allied Chemical Corporation. Dr. Maurice H. Bigelow was appointed vice president. Formerly technical director, Dr. Bigelow will continue to be head of Barrett's research and development department and will be in the New York office.

Brewster Company. Bill Pickering, veteran sales executive, has been named sales manager. Harry B. Marioneaux, first vice president and general manager, announced. Pickering, who has more than 25 years in the oil field, including 10 years in field service, has a broad sales experience covering heavy equipment in all phases of drilling, production and pipeline supplies. Before joining Brewster four years ago, he was associated with Bethlehem Supply Company for 10 years and previously was in the production department of Placid Oil Company.

F. H. Maloney Company. Ben R. Medford, Jr., has been appointed a field sales engineer. He will operate out of the Tulsa, Oklahoma, office. Prior to this appointment, he has been plant sales engineer at the main office. Replacing Medford in the Houston office is Lee Dawson.

Hillmac, division of American Coldset Corporation. Clifford M. Brake was added to the sales force of the Denver, Colorado, region.

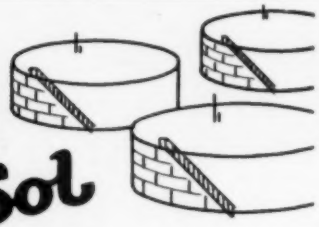
McCullough Tool Company. William Newashe, Jr., branch manager, formerly in charge of operations in Big Piney/Rock Springs, Wyoming, area, has been transferred to Cortez, Colorado, branch office.

Layne & Bowler, Inc. of Memphis. At a recent meeting of the board, Edward J. Rogers, president and general manager of Layne-Northwest Company of Milwaukee, Wisconsin, was elected chairman of the board.

C. E. Ponkey of Dallas, Texas, was elected executive vice president. Ponkey was educated in Detroit, University of Detroit, two years commerce and finance and four years aeronautical engineering. He was with Dallas Tank Company of Dallas recently. In the past he has been associated with Dresser Associates, Sheldrick Manufacturing Company and Excello Corporation.

Joy Manufacturing Company, Oil Field Drill Division. Lenard D. Snyder has been appointed product manager and Constantine M. Xeros has been named to succeed Snyder as chief engineer. In his new post, Snyder will direct the division's engineering and manufacturing operations while Xeros will be in charge of the design of portable drilling rigs.

RECLAIM TANK BOTTOMS with BrakeSol



the most effective chemical for treating PARAFFIN

The money you make on reclaimed tank bottoms by using BRAKESOL will be substantially more than the cost of treating . . . including chemical and labor. Safe for use in production, pipeline and refinery equipment . . . Contains no chlorides, sulphides or other halides. BRAKESOL Treating Engineers have the experience and know-how to do a successful job. Contact them now!

Treating Engineers Available at These Locations

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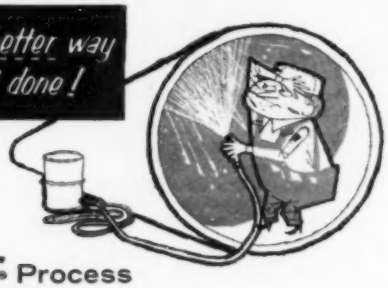
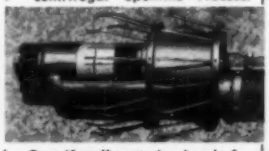
EXPORT DISTRIBUTOR: THE NATIONAL SUPPLY CO., EXPORT DIVISION

there's a better way to get it done!



by "Spunline" Process

Cement mortar lining is applied uniformly by centrifugal "Spunline" Process.



Centrifugally rotating head of Spunline applicator provides uninterrupted continuity.

Newly developed Spunline Process . . . a combination of the world famous Tate and centrifugal processes . . . is now available for cement mortar lining of 6" to 16" diameter pipes "in place." Permits application of thinner lining with closer tolerance . . . permits lining past smaller openings and corporation stops . . . through many bends and certain fittings. Particularly advantageous with cast iron pipe . . . restores flow coefficients, protects against corrosion, contamination. *Write today for full information.*

Specializing in Pipe Protection Problems
- Tate, Centriline, Spunline "In Place" Interior Cement Mortar Lining
- "In Plant" and "Railhead" Centrifugal Spinning of Cement Mortar or Coal Tar Linings Somastic(R) Exterior Coating
- Pipe Wrapping - Reclamation - Removal of Old Wrapping, Straightening, Blasting, Beveling, Testing

PIPE LININGS
A Division of American Pipe and Construction Co.
2414 East 223 St. (P. O. Box 457)
Wilmington, California

American Iron and Machine Works. Leroy Burner was appointed special representative with headquarters at Houston, Texas. He was previously manager of machinery sales for a major supply company. Raif Erisken will headquarter in Rome, Italy, and holds the title of area director, export sales. Before joining American Iron, he was with Ideco in New York as co-manager of export sales in the Eastern Hemisphere.

Celanese Corporation of America. Robert V. Butts became salary administration manager and Clifford C. Whitney was appointed employee development manager in the personnel administration department.

Du Pont. W. Samuel Carpenter, III, director of sales, Petroleum Chemicals Division, has become assistant general manager of the company's Electrochemicals department. He succeeds Charles B. McCoy who has been named general manager of the Elastomer Chemicals department.

Chain Belt Company. O. W. Carpenter was elected president. He succeeds L. B. McKnight who has been president of the company since 1953.

Dayton Rubber Company. Robert G. Burson was named assistant general sales manager for the company's mechanical goods division.

Boston Woven Hose & Rubber Company Division of American Biltrite Rubber Company, Inc. James N. Mason has been named to succeed John M. Bierer as president and general manager of the parent company's Boston Woven Hose & Rubber Co. Division. He was formerly executive vice president.

Ohio Injector Company. William H. Fellows was named national sales manager, G. Richard Winder, vice president of marketing announced. Fellows, who was located at Washington as an engineer with the National Bureau of Standards, most recently has been a vice president of Abrasive and Metals Products Company, Detroit.

Bertram J. Milleville was appointed director of engineering and research. He will head the company's recently announced product development program, Roger E. Bremer, executive vice president announced.

E. G. Blaylock, Tulsa industrial engineer, is manager of a new industrial valve distribution district for the southwest and Gulf states area, which extends from Kansas to the Gulf states.

W. C. Norris, Manufacturer, Division of Dover Corporation. Earl Carpenter, who has 14 years experience in oilfield supply sales and store management, has joined the sales staff. He will work in Oklahoma and Kansas under Jack Getty, division manager, and will headquarter in Tulsa.

Minneapolis-Honeywell Regulator Company. Harvey W. Odom has been named sales manager of the industrial branch office in New Orleans. He will transfer from the Wichita, Kansas, office, where he has served as branch industrial manager for the last several years, and will be succeeded there by Eldred E. Jones.

Babcock & Wilcox Company. Carl Claus was elected a vice president. He will continue to direct the activities of the staff division, which provides essential services to all divisions of the company.

Clayton Mark & Company. Carl D. Hanson has been appointed unions sales representative in the Gulf Coast states. He will represent the Evanston, Illinois, manufacturer of forged steel unions and forged steel fittings in Southeastern Texas, Arkansas, Alabama, Louisiana, and Mississippi.

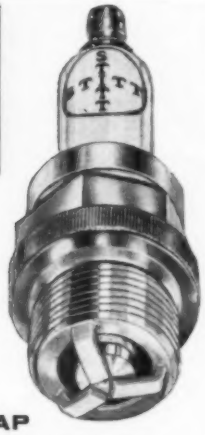
Beckman Instruments' Scientific Instruments Division. Appointment of Dr. William S. Gallaway as senior physicist was announced. He will supervise exploratory research into advanced types of analytical instrumentation for scientific, industrial and medical laboratories. He also will direct evaluation of the design and performance of new instrumentation developed by the Fullerton-based division.

Grove Valve and Regulator Company. New members of the field sales engineering staff are: A. E. Hildebrand, Los Angeles, California; J. C. Hutchison, Odessa, Texas; W. B. Bowden, Houston, Texas; W. S. George, Farmington, New Mexico.

General Electric. Allan I. Benson has been promoted to manager of scientific applications, one of the eight sections of the General Electric computer department and the section responsible for operation of the Arizona State computer center, Tempe. Benson also will continue until further notice supervision of his previous position as manager of the computer center, a sub-section of scientific applications.

U. S. Steel's Oil Well Supply Division. James M. Reid was appointed district representative at Duncan, Oklahoma. Prior to his present appointment he was assistant district manager at this location.

STITT



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STITT IGNITION CO.
Dept. Columbus, Ohio

STITT MAKES HEAVY DUTY INDUSTRIAL SPARK PLUGS

This ball foretells less pump downtime

Actual production records prove—Kennametal* API Balls and Seats stay on the job 3 to 5 times longer than "Super Alloys," and up to 20 times longer than steel. See Kennametal's new high-polish, "crystal finish" seat.

Kennametal Balls and Seats are stocked as replacement parts by most pump manufacturers —available for immediate delivery. Be sure to specify KENNAMETAL. For descriptive leaflet write to KENNAMETAL INC., Latrobe, Pa.

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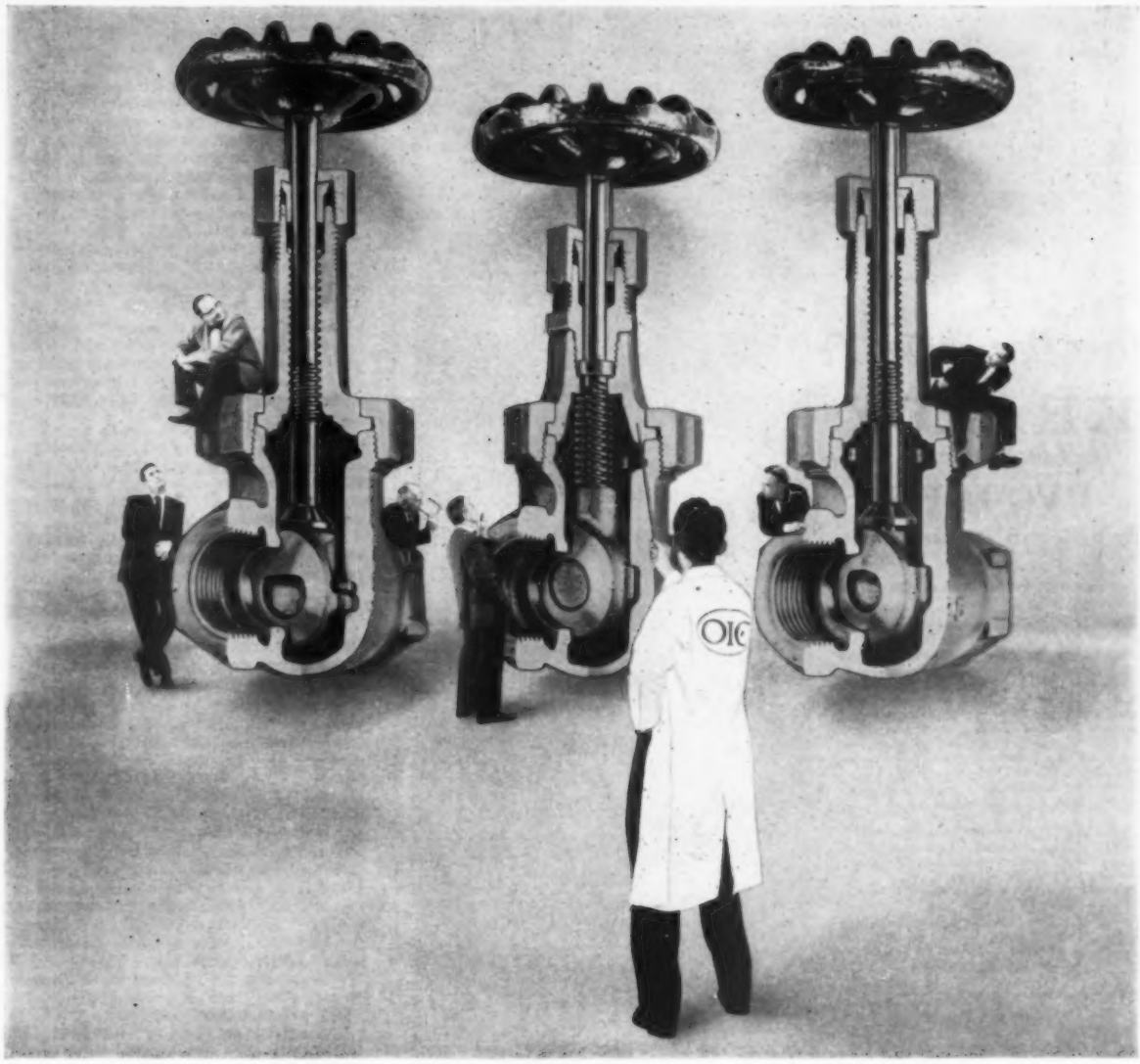
...3 gate valve types in 3 pressure classes, gentlemen, all with safe, efficient (and effective) union ring joints



125 lb.—150 lb.—200 lb. OIC bronze gates . . . the most *modern*, complete line you'll find anywhere. Solid wedge—split wedge—rising or non-rising stems. All, of course, featuring OIC *alloy-40* stems which OUTLAST ORDINARY VALVE STEMS 10 to 1!

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OIC **VALVES** | BRONZE, IRON, FORGED AND CAST STEEL, LUBRICATED PLUG VALVES

Trade Parade

Harrisburg Sales & Service, Inc. Robert C. Holden has been named vice president and general manager, with headquarters in Houston, location of the company's manufacturing facilities. The company manufactures and markets Diamond Hard products and oil field specialties, including liners, piston rods, pistons, and accessories for all oil field pumps. Harrisburg's new official has been sales engineer in Dallas for Mid-Continent Supply Company, which he first joined in 1948.

Foxboro Company. John E. Hewson has been appointed manager of the New York sales region, supervising instrument sales activities in the area including New York City and sections of Connecticut and New Jersey. He succeeds E. H. Huckman, who recently assumed the position of assistant field sales manager for the industrial instrument firm.

Schlumberger Well Surveying Corporation. H. C. Thomason, formerly district manager at Medicine Lodge, Montana, has been named senior sales engineer at Great Bend, Kansas.

Radio Corporation of America. D. O. Reinert was named to the newly created position of manager, mobile and microwave service sales. Technical Products department, RCA Service Company. He will be responsible for the sale of installation and maintenance for RCA mobile and microwave communications systems.

American Cyanamid Company. Dr. Theodore M. Vial was appointed manager of technical service of the rubber chemicals department, organic chemical division.

Dunlap Manufacturing Company. L. E. Upton has been promoted to general superintendent at the Tulsa plant. In his new capacity, Upton will be responsible for research and experimental design in industrial shutters and controls.

Dresser Industries. Robert D. Crane has been appointed assistant director of purchases. He moves to Dallas from his position as manager of purchases for Dresser Manufacturing Division, Bradford, Pennsylvania.

Dresser Manufacturing announces the following personnel changes: Donald L. Garrison, southeastern sales representative for the gas market with headquarters in Atlanta, Georgia, has been transferred to Chicago as district manager — gas.

James L. Mattern, field consultant in the plastic products department in Bradford, has been transferred to Atlanta, Georgia, as Southeastern district manager — gas.

Richard T. Alt, North Central sales representative — gas, with headquarters in Milwaukee, has been appointed North Central district manager — gas, with headquarters in Minneapolis.

Dow Chemical Company. James E. Norbury, Jr., has been promoted to supervisor of industrial chemicals sales at the Boston office. He has been on the Boston sales staff since he joined the company in 1950.

De Laval Steam Turbine Company. John P. Woolridge was elected director, H. G. Bauer, executive vice president, and Harry Engvall, vice president of engineering at the annual meeting.

Bauer is a member of the board of directors and has been serving as vice president and general sales manager. He will continue his duties as general sales manager. He joined De Laval in 1937.

W. F. Senkus was transferred from the Chicago district sales office to headquarters Turbine Sales Department in Trenton, New Jersey.

Dayton Rubber Company. Millard D. Coate was named manager of customer service and Lester J. Adams appointed merchandise manager for Mechanical Goods division. Both positions have been created as a result of expanded operations.

Norman G. Lever, former Midwest regional manager, has been promoted to sales manager for the Industrial Division. Thomas E. Farrell will succeed Lever in the Midwest region with headquarters in Chicago. K. C. Sparks has been named regional manager for the West Coast, succeeding K. L. Harvey.

For the Plastics Division two sales engineers have been appointed, James E. Skrna will cover the midwest region with headquarters in Chicago. John G. Senese will cover the Eastern territory with headquarters in New York.

B. F. Goodrich. J. Terry Taylor, formerly manager of fuel cell operations in B. F. Goodrich Aviation Products, was appointed manager of product service and field engineering for B. F. Goodrich Tire Company.

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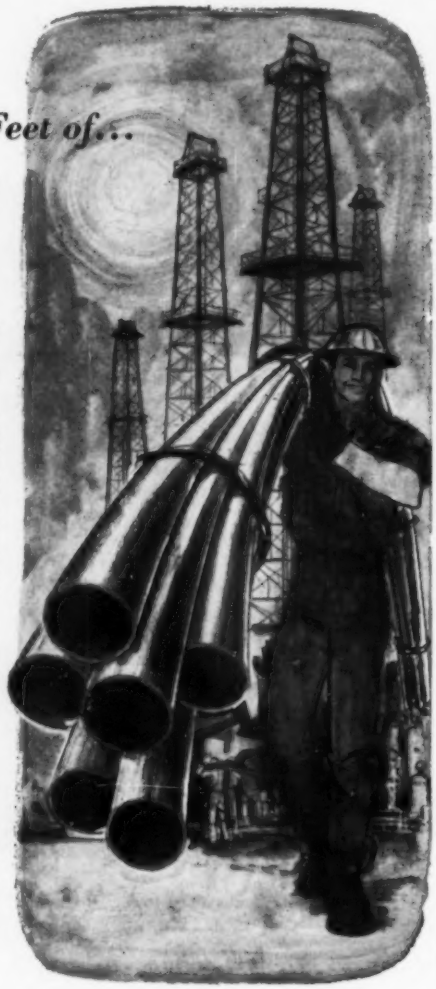
KRALOY

HIGH-IMPACT

PVC PIPE

in oil-country use today



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KRALOY is the most experienced manufacturer of PVC plastic pipe for the petroleum industry. The first polyvinyl chloride lead line installed in this country—at Great Bend, Kansas—was Kraloy Pipe. Kraloy High-Impact PVC today is preferred by production men for maintenance-free service in lead lines and disposal systems. Kraloy customers use Kraloy High-Impact PVC pipe for lead lines, gas lines, and salt water lines because Kraloy normally eliminates (1) sulphur corrosion due to sour crude, (2) paraffin buildup, (3) corrosion and scale, (4) trouble from soil electrolysis.

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To insure quality control, random samples of Kraloy Plastic Pipe are tested daily in Kraloy's own laboratory for burst pressure, impact resistance, and tensile strength under standard ASTM specifications.

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John Massey, Jr., P. O. Box 2224
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Ross Howell, 209 E. Scott St.
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The Becker Sales Company, 3013 S. High St.
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WANTED — Drilling superintendent for 2-year foreign operation. Excellent salary. Send complete resume and references. All replies held strictly confidential.

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Petroleum Engineer
Dallas, Texas

Meetings

June 10-12—**Appalachian Underground Corrosion short course,** West Virginia University, Morgantown, W. Va.

June 11-14—**National Society of Professional Engineers,** annual meet, Chase-Park Plaza hotels, St. Louis, Mo.

June 22-25—**American Institute of Chemical Engineers,** 50th anniversary meeting, Bellevue-Stratford Hotel, Philadelphia, Pa.

June 25-26—**WPRA,** Mid-Continent regional technical-industrial relations meeting, Broadview Hotel, Wichita, Kans.

June 28-July 2—**Petroleum Equipment Suppliers Assn.,** annual meeting, Chateau Frontenac, Quebec, Can.

Aug. 18-21—**ASME,** Heat Transfer-AIChE conf., Northwestern University, Evanston, Ill.

Aug. 25-27—**Appalachian Gas Measurement Short Course,** University of West Virginia, Morgantown, W. Va.

Sept. 9-12—**10th National Chemical Exposition,** Chicago section of the American Chemical Society, International Amphitheatre, Chicago, Ill.

Sept. 10-12—**Mid-Continent Oil & Gas Assn.,** Mississippi-Alabama annual, Buena Vista Hotel, Biloxi, Miss.

Sept. 15-19—**13th Annual Instrument-Automation Conf. & Exhibit,** Philadelphia, Pa.

Sept. 18-20—**Rocky Mountain Assn. of Geologists,** symposium of Pennsylvanian rocks, field trip of Paradox Basin, northwest and eastern Colorado.

Sept. 21-24—**ASME,** petroleum mechanical engineering conf., Cosmopolitan Hotel, Denver, Colorado.

Sept. 21-24—**American Institute of Chemical Engineers,** regional meeting, Hotel Utah, Salt Lake City, U.

Sept. 24-25—**WPRA,** Rocky Mountain regional technical-industrial relations meet, Henning Hotel, Casper, Wyo.

Sept. 25-26—**Mid-Continent Oil & Gas Assn.,** Arkansas and Louisiana annual, Roosevelt Hotel, New Orleans, La.

Oct. 1-2—**WPRA,** 3rd annual stream pollution and waste disposal conf., Lassen Hotel, Wichita, Kans.

Oct. 1-3—**AAODC,** 18th annual, Adolphus and Baker hotels, Dallas, Tex.

Oct. 5-8—**Society of Petroleum Engineers of AIME,** fall meeting, Houston, Tex.

Oct. 7-8—**Texas Mid-Continent Oil & Gas Assn.,** 39th annual, Statler Hilton Hotel, Dallas, Tex.

Oct. 12-18—**Oil Progress Week**

Oct. 13-15—**AGA,** 40th annual conf., Traymore Hotel, Atlantic City, N. Y.

Oct. 13-16—**Society of Exploration Geophysicists,** annual meeting, Gunter Hotel, San Antonio, Tex.

Oct. 16-17—**AIME, Southern California Petroleum Section,** fall meeting, Biltmore Hotel, Los Angeles, Calif.

Oct. 16-19—**Permian Basin Oil Show,** Odessa, Tex.

Oct. 20-24—**NACE,** annual conf. & exhibition of South Central Region, Roosevelt Hotel, New Orleans, La.

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WANTED—Assistant manager, drilling superintendent and petroleum engineer, all in one man, to supervise 2½ year foreign one-rig drilling operation. Top salary. Bonus. Send complete resume and references. All replies held strictly confidential.

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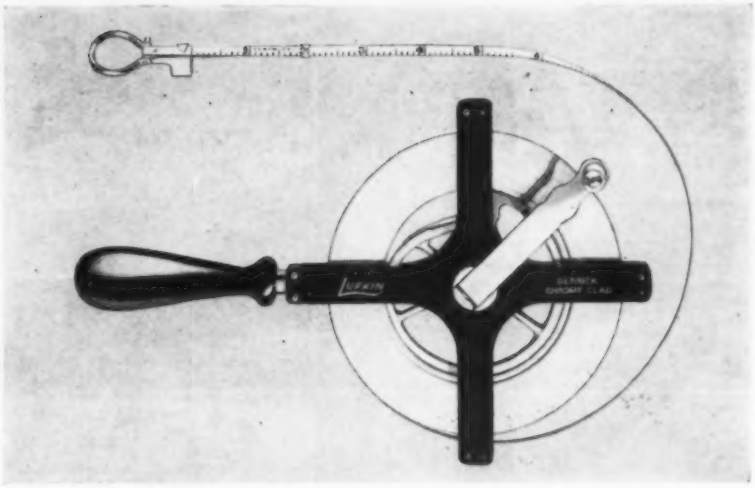

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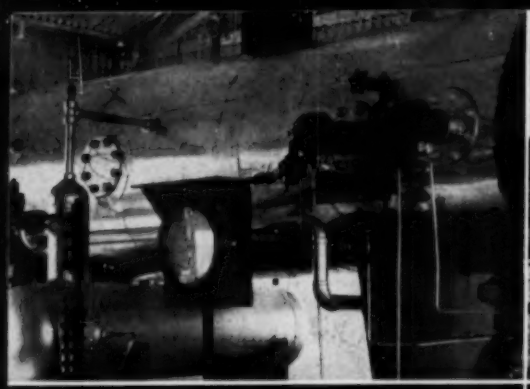
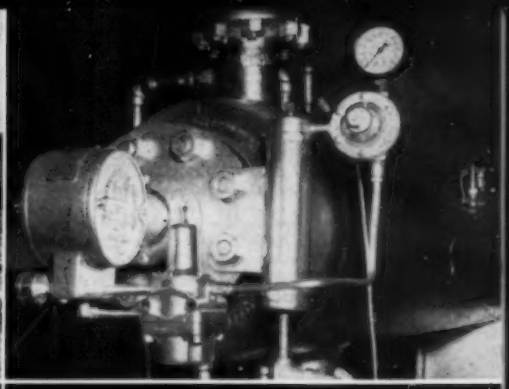


Controlling distillate and water on an LTX® unit in Mississippi.

Controlling oil production on High and Low Pressure Stage Separation unit in Louisiana.

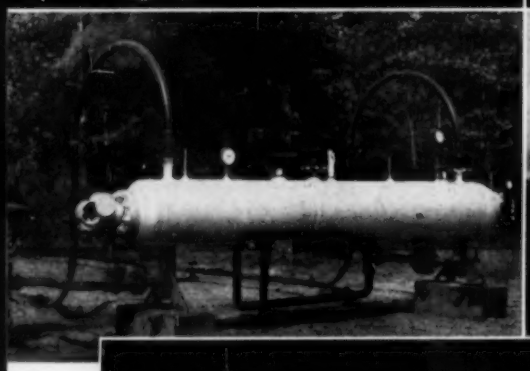
Controlling oil and water in a Monotube Oil, Gas and Water Separator in La.

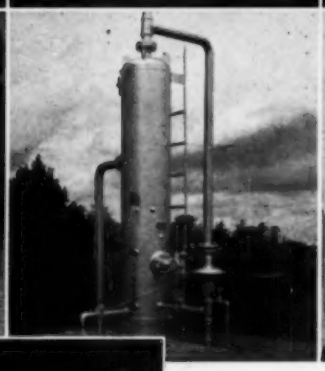
Controlling oil production in Vertical High Pressure Separator in Mississippi.

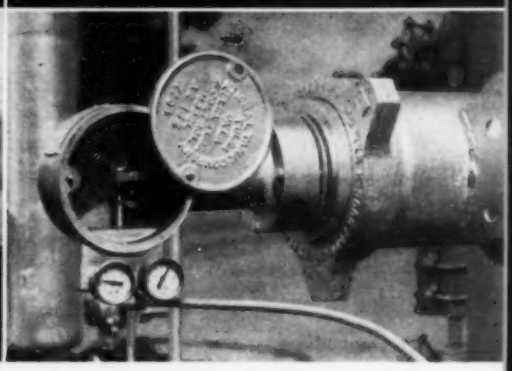


Controlling distillate production in a High Pressure Monotube® Separator in Oklahoma.

Controlling saturated glycol in contactor tower of Glycol Dehydration unit in Oklahoma.

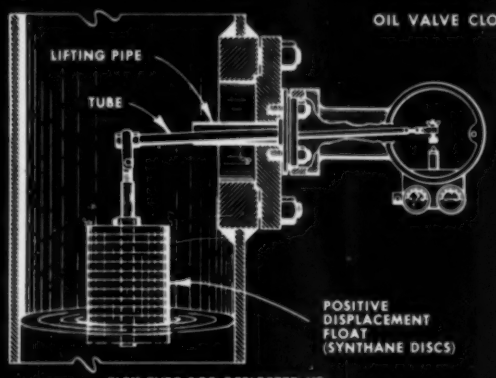






WHY FLEX TUBE®

is the most reliable liquid level control



FLEX TUBE ROD DEFLECTED UP
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Patented

- Accurate
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- Easy adjustment
- No intricate stuffing box
- No precision rotating parts
- No knife-edge fulcrum points
- Positive displacement non-corrosive float
- All parts of stainless steel with cast aluminum case
- Accurate throttling control Or (where desirable) will intermit
- Reduces lag to minimum
- Maintains an inner-face between liquid hydrocarbons
- Working pressures from 0 psi to 6000 psi
- Pressure opening or pressure closing operation

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1. A cantilever beam will flex or bend when a concentrated load is applied to the end opposite to that which is securely fixed.
2. A solid body, or float, when immersed in a liquid, will decrease in weight by the weight of the liquid displaced.

SIMPLE OPERATION

As fluid level rises, the compacted FLEX TUBE float discs rise, gradually closing the adjustable bleeder nozzle, causing a pressure build-up to the control line which activates the dump valve, and as level retires, the float discs follow for throttling or intermittent control.

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.....PLUS A GOOD CREW

MAKES Satisfied CUSTOMERS

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Satisfied customers are the greatest asset a well servicing contractor can have — particularly when times are rough and many yards are full of units. Good equipment, plus good crews, is one of the most important ingredients in gaining satisfied and repeat customers.

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Franks Cruisers obtainable in models 2,500 to 12,000 ft. Single or double drum, single or double pole mast.

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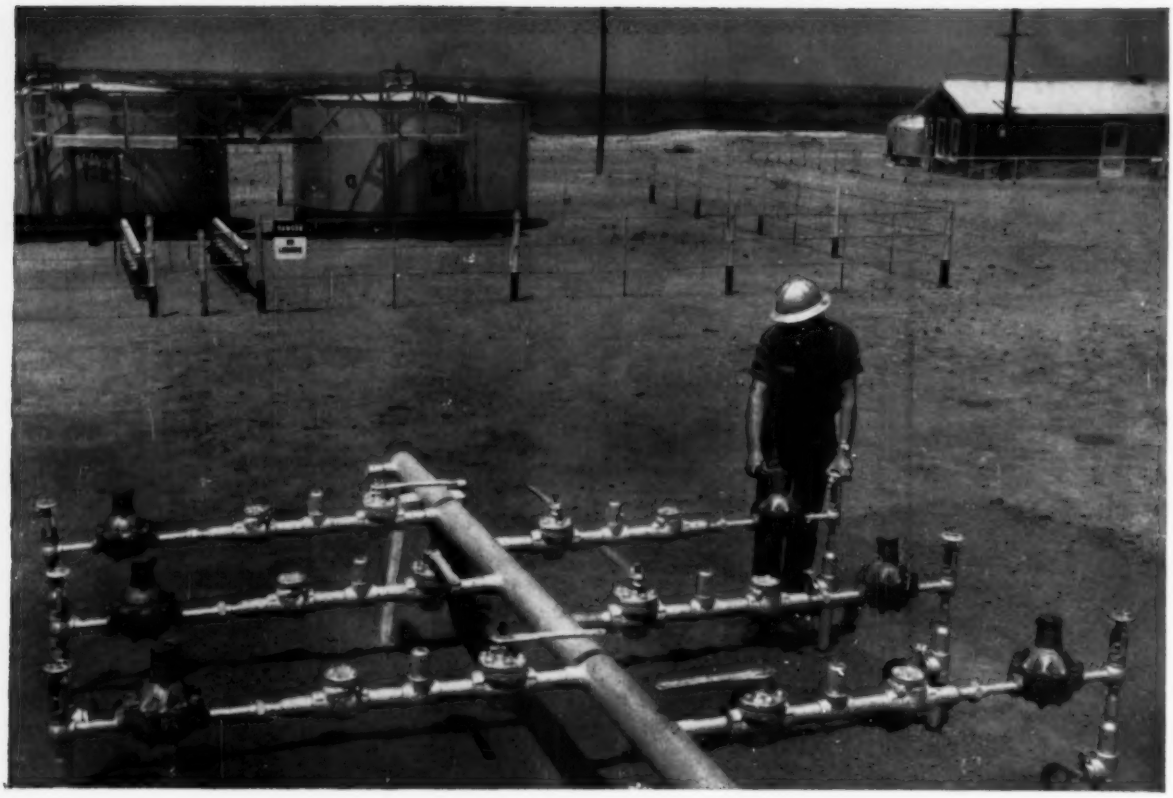

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Of Things To Come . . . In Oil

LONG RANGE GROWTH, VIGOROUS, said R. G. Follis, board chairman for Standard of California, in describing oil industry's future before a recent stockholders meeting. Petroleum and natural gas will remain best sources of energy for a large segment of free world's requirements, he projected. He expressed confidence that the general economy would return to normal in a few months.

DUPLICATING LOGS BY RADIO, similar to wire photo, is one way to cut down expensive rig time . . . especially offshore. Still in the experimental stage, this idea will reduce long delays in delivering duplicate logs for making decisions as the well is drilled.

COOL RECEPTION DUE ARCTIC LEASE OFFERING now being readied by Interior Department, say many oil attorneys. Stipulations are too severe . . . although waivers might be considered if conditions become "unnecessarily burdensome." Some 20 million acres above the Alaskan arctic circle are involved including the Gubik gas field area.

GAS BILL PASSAGE — NEXT YEAR, forecasts IPAA. Optimism is based on agreement between long-line gas transmission companies and coal industry . . . biggest adversary of long-pending gas measure. Pipelines purportedly agreed not to dump gas "below cost" in eastern coal market. No attempt for passage this year expected, say backers of Harris Bill.

$8 BILLION BUDGETED FOR '58 capital expenditures by U. S. oil companies. Of this amount, nearly $5.5 billion will be for exploration, drilling and production. 34 companies showed a 2 percent increase this year over last year's expenditure, even though the total is down slightly over last year's industry-wide figures.

NEW TEXAS PIPELINE RULES may be forced into the making by the Railroad Commission . . . "unless pipelines voluntarily fulfill their responsibilities." Groundwork is being laid by formulation of new code whereby transmission firms must connect to existing producing oil wells. Commissioner Wm. J. Murray, indicated that carriers must abolish "dedicated market" contract clauses if gas industry is to grow. If not, Murray hinted, RRC may be forced to use its latent powers over pipelines.

MORE MICROWAVE FOR OIL PRODUCERS in the works by several companies, mostly on the Gulf Coast. Magnolia's existing offshore system is to be joined with a large Conoco-operated CATC Group network under construction. Shell plans similar system in Mississippi Delta. Bell Telephone has proposed coast-wise communications system on a subscription basis. Microwave usage has some room on ultra-high frequency band spectrum . . . regular frequency communication band already overcrowded.

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. . . still the world's most powerful gun, due to its many year-to-year improvements.

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. . . pioneered most effective field results—accomplished jet acceptance in oil fields.

1949 — **Developed NEW GAMMA RAY INSTRUMENTS**
. . . with quantitative calibration for more precise radioactive logging of formations.

1950 — **Developed SIMULTANEOUS RADIATION LOGGING**
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1951 — **Developed FOUR-RESISTIVITY-CURVE ELECTRICAL LOG**
. . . employing an S. P. curve of greater detail for more accurate analysis of formations.

1952 — **Developed JUMBO SIDEWALL CORE SAMPLING**
. . . with larger cores more precisely located through the S. P. curve of electrical log.

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1954 — **Developed "MIGHTY MOUSE"® CHAMP OF THE MIDGET GUNS**
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Developed ABSOLUTE CALIBRATION FOR RADIATION LOGGING
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1955 — **Developed SIMULTANEOUS 4-RESISTIVITY CURVE ELECTRICAL LOG**
. . . simultaneously recording 4 resistivity curves, giving more complete formation evaluation than ever.

1956 — **Developed NEW HIGH-PRECISION MICRO-CALIPER SURVEY**
. . . for simultaneously logging resistivity of materials on walls of hole and recording hole-diameters.

Developed SUPER "MIGHTY MOUSE"® TUBING PERFORATORS
. . . in 1¾" and 2⅛" O.D. sizes, both the world's most powerful fixed-diameter expendable tubing guns.

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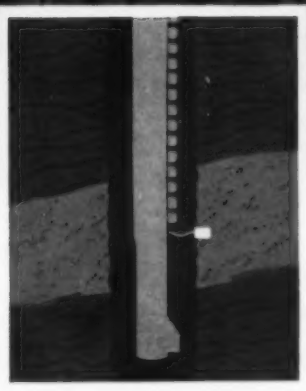

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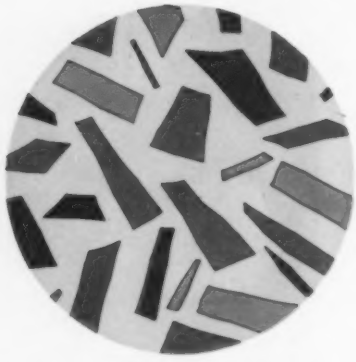
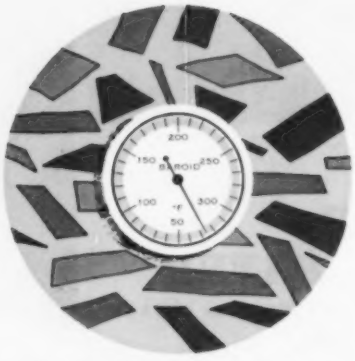


THINS MUD WITHOUT DILUTION



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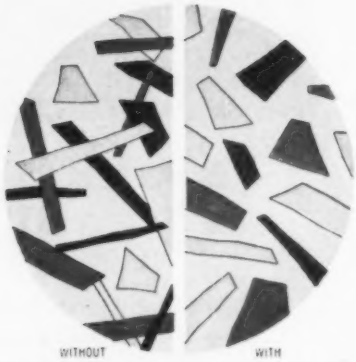

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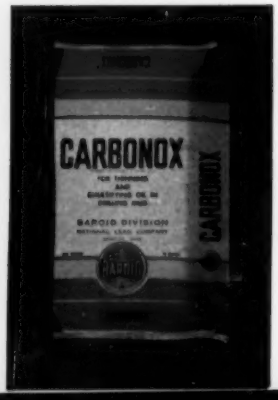

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Rings reach maximum size in the well within a few hours.

Dimensional Compensation during the manufacturing process assures the uniform working fit obtained with Martin Split Rings.

The Martin Ring Size Guide Table* assures proper ring size selection for various gravities, temperatures and sand and water content.

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The gaps between the Martin Rings cause fluid turbulence which slows down slippage past the Martin Plunger — just as a rough road slows down your driving speed. Actually, the Martin Plunger maintains pumping efficiency with a looser fit than is possible with a smooth surface plunger.

* See the complete Martin Catalog and instructions in the 1957 Composite Catalog.

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MISSION VALVES WERE USED

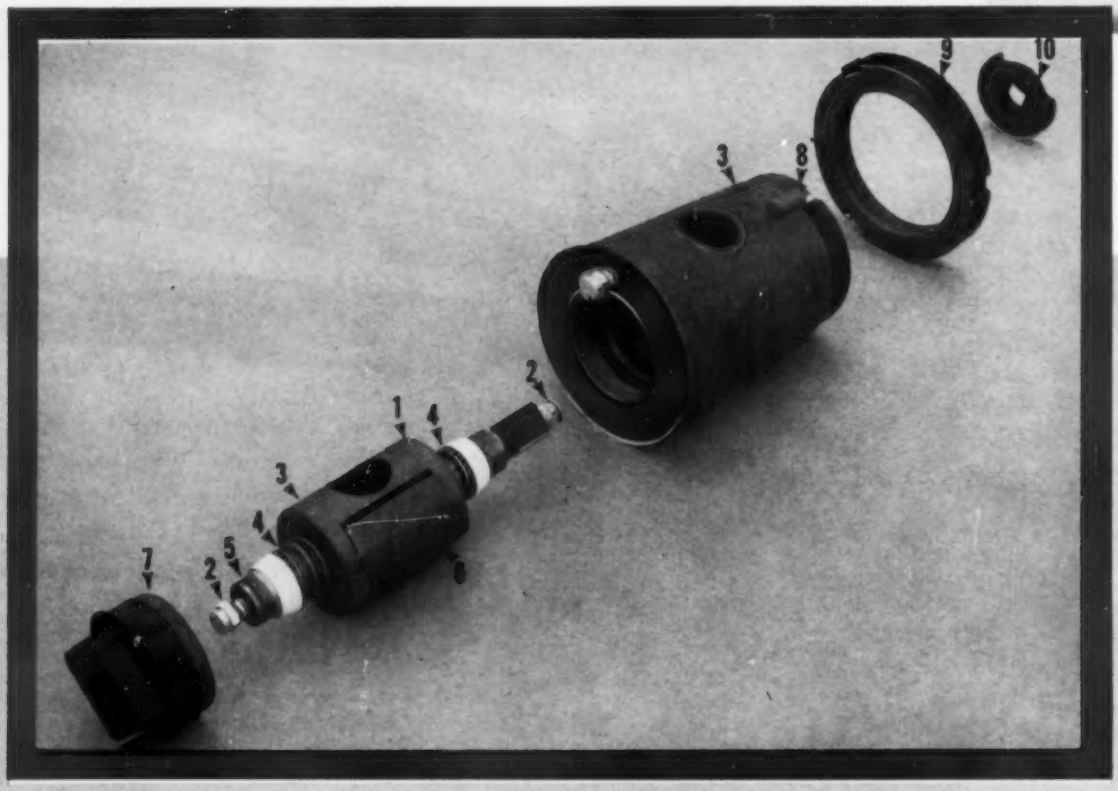
MISSION WAS READY when asked for a valve that could be used in an ultra-pressure unitized Christmas Tree. Mission had a balanced stem valve—easily adaptable to a unitized tree or manifold—that had been proven by three years laboratory testing and field use. A leading service company has been using these valves in service so severe that no other valve had been successful.

These valves were easily adapted to the unitized tree design because they were compact, simple, dependable, and trouble-free. Accordingly, Mission engineers designed a tapered body with no flanges or threaded connections. In addition to the metal-to-metal tapered seal, various combinations of resilient seals have been developed to meet producers requirements.

Largely because of these valves, the unitized design promises to be the greatest Christmas Tree advance in years.

Mission makes an extensive line of valves in a variety of pressure ratings and sizes. This Mission Valve can be adapted to unitized tree designs of other manufacturers. In addition, Mission Valves are well adapted to all Christmas Tree designs—both unitized and conventional—both single and multiple string. They are also used on high pressure manifolds and for drill stem test valves.

For more information on the Mission Valve used on the first O-C-T UNITREE, see the exploded view shown below. For full information on the complete line of Mission Valves, contact your Mission representative, your supply store, or your well head manufacturer.



This photograph shows important features of a partially disassembled Mission 30,000-pound test valve. These features include: (1) the split, wedge-proof, cylindrical core, (2) the high-pressure grease fittings that fill the automatic lubrication system and pack the space behind both stem packings, (3) the Missionized® core and body surfaces that minimize friction and prevent galling, (4) the springs that supply an initial load on the tapered Teflon-and-bronze stem sealing assemblies, (5) the resilient supplementary stem seals, (6) the half-circle grease groove which mates with another half-circle groove in the body when the valve is closed, (7) the cover which features a metal-to-metal seal instead of plastic or other non-metallic seals, (8) the guide pin which aligns the valve in the tree, (9) the locking ring which holds the valve in place and (10) the external stop which also indicates whether the valve is open or closed. Most features of this valve are also included in standard Mission Valves of lower pressure ratings.

*Trademark of Oil Center Tool Company

IN THE FIRST UNITIZED TREE

A 30,000-pound test Mission Valve has been removed from the first O-C-T UNITREE*. Notice the balanced stem construction, the full round opening, the tapered "zero clearance" body, the locking ring for the valve and one version of the pressure-actuated resilient seal arrangements around the flow passage.

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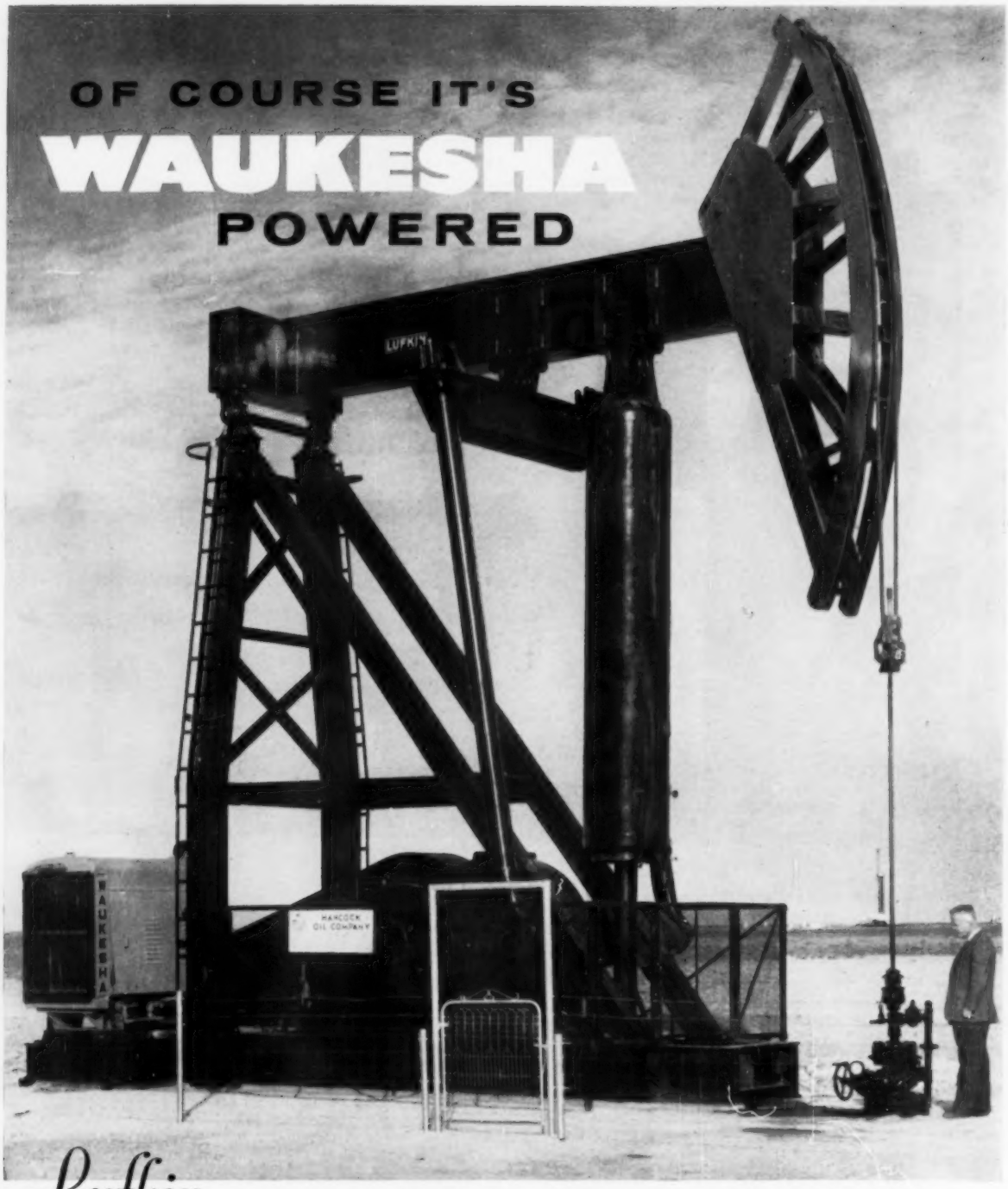

Lufkin . . . the largest beam type pumping unit built

Owned by the Hancock Oil Company and operating on their lease near Tatum, New Mexico — this A-1500D-192-42 air balanced Lufkin pumping unit has a 16-ft. stroke and a gear box with a capacity of 1,500,000 inch pounds. It is the largest beam type pumping unit built. It has a Waukesha Long-Life WAKU Oil Field Gas Power Unit, with an 1197 cu. in. six-cylinder engine, 6¼-in. bore x 6½-in. stroke. This is the second of these large units bought by Hancock Oil Company. That says a lot for the satisfaction-in-use of this reliable Lufkin-Waukesha combination.

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Cutaway diagram of rubber sleeve core barrel that delivers "packaged as cut" core.

The core is actually packaged by the rubber sleeve within the barrel delivering completely undisturbed core that can be handled without crumbling or other physical disturbance and is not altered by exposure.

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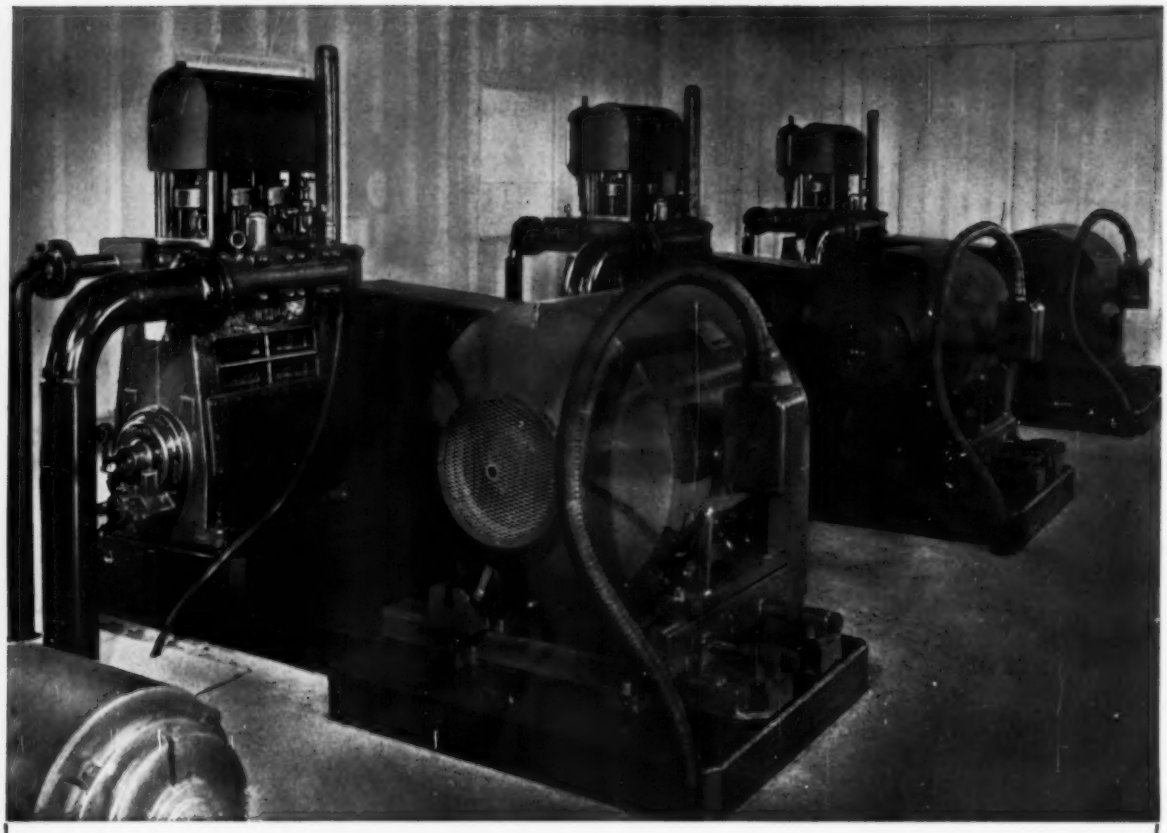

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PUMPS INSTALLED: April 1953

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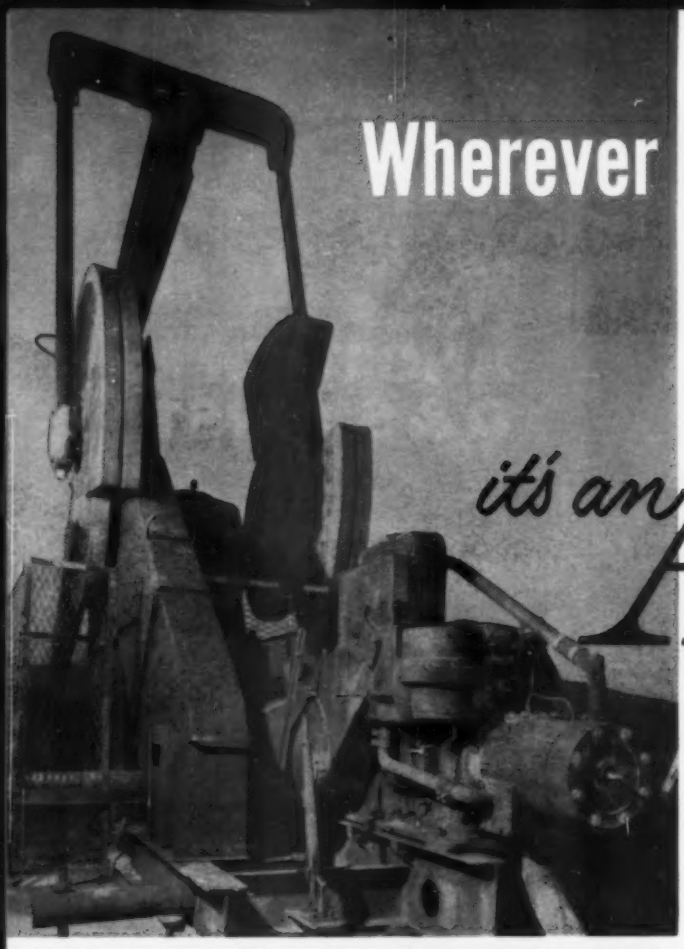

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The Super Giant Rig features Diamond Roller Chains on both transmission and compound.

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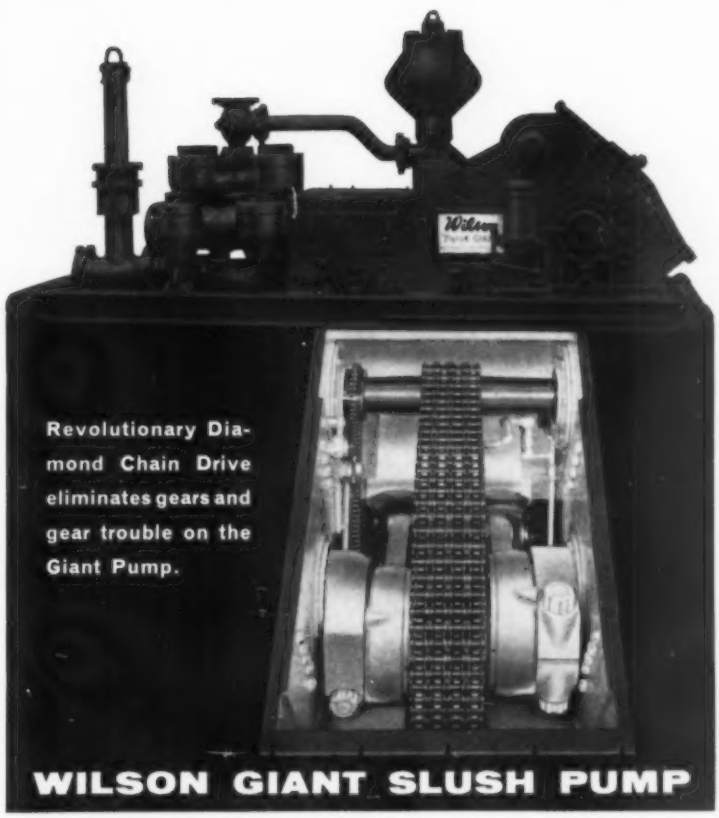
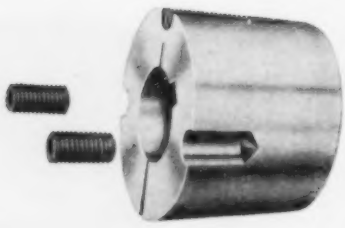


Revolutionary Diamond Chain Drive eliminates gears and gear trouble on the Giant Pump.

WILSON GIANT SLUSH PUMP



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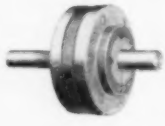
Change from sheaves to sprockets to couplings to conveyor pulleys				

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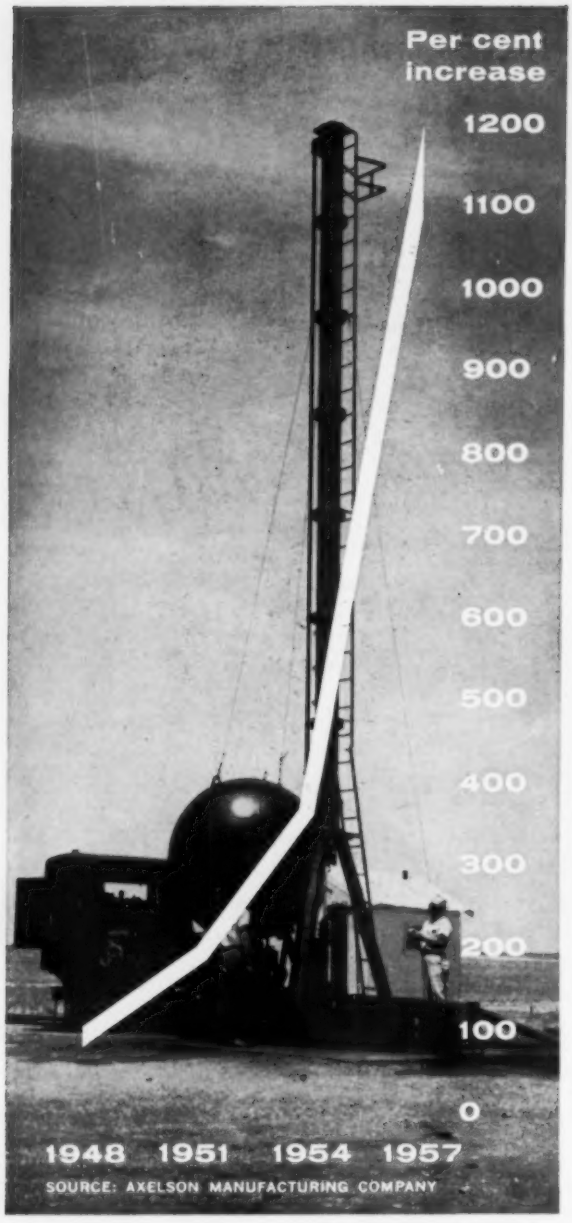

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HYDRAX units are backed by a factory-trained service organization.

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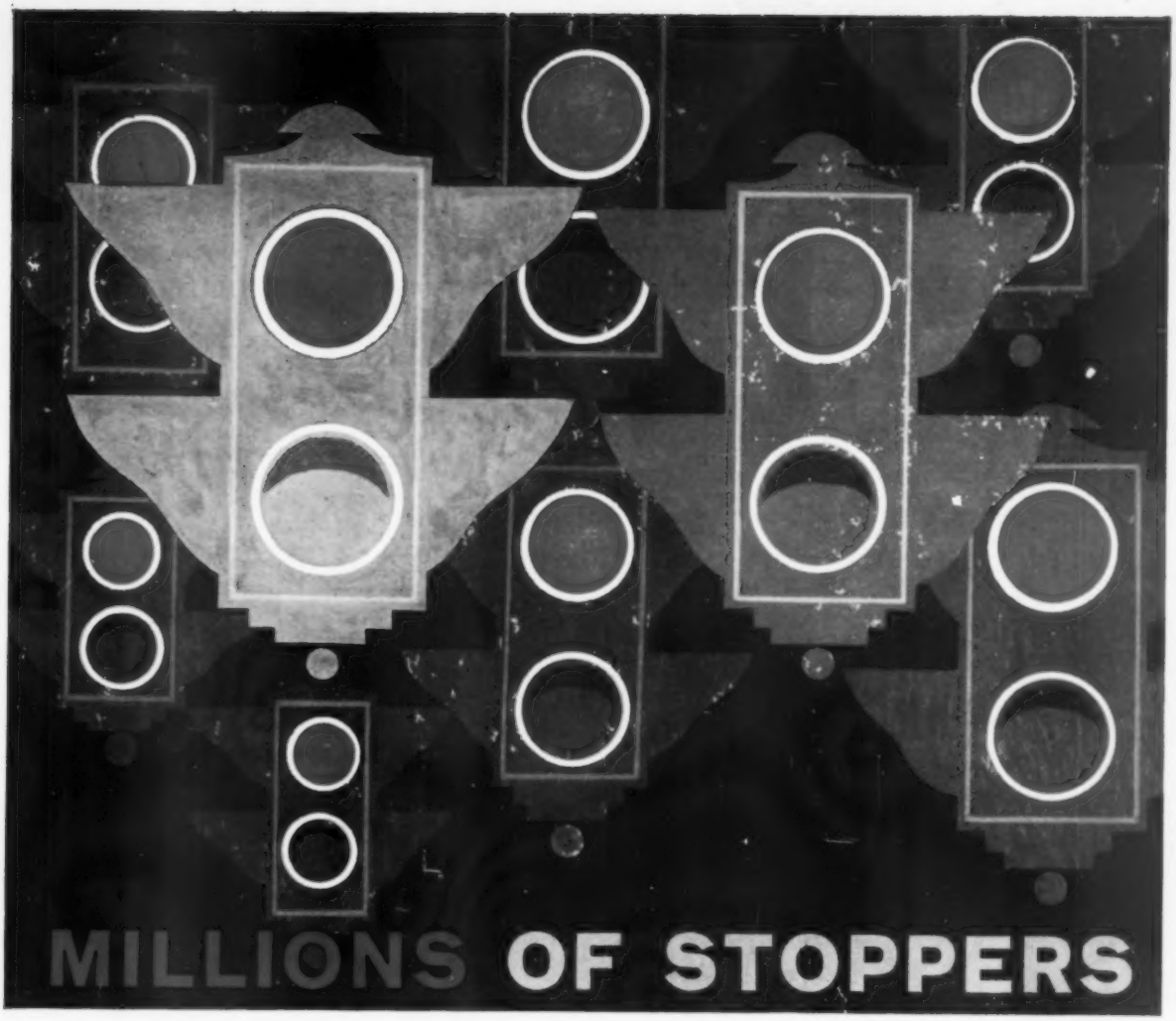

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- Obtains larger fractures per volume of treatment, or the same-sized fracture with a lesser volume of fracturing oil.
- Decreases friction loss because of the low viscosity of Adomite-treated fluids.
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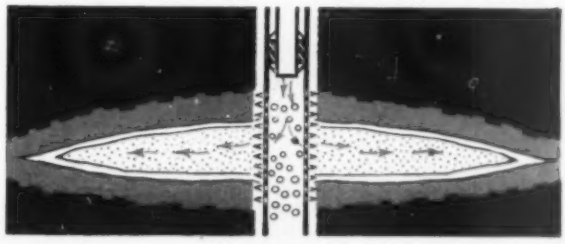

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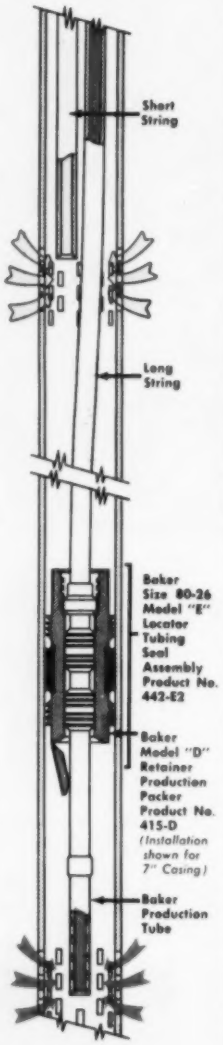
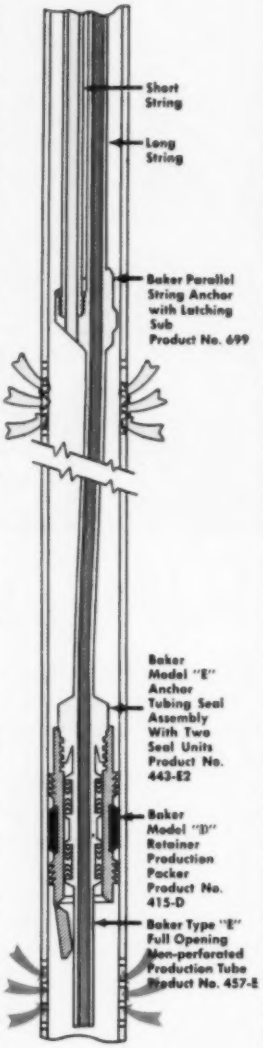

Short String
Long String
Baker Size 80-26 Model "E" Locator Tubing Seal Assembly Product No. 442-E2
Baker Model "D" Retainer Production Packer Product No. 415-D
(Installation shown for 7" Casing)
Baker Production Tube

Permits removal of either string independently of the other regardless of sequence. Full-Opening (Tubing I.D.) Long String to lower zone.

DUAL ZONE parallel string SHORT STRING ANCHORED


Short String
Long String
Baker Parallel String Anchor with Latching Sub Product No. 699
Baker Model "E" Anchor Tubing Seal Assembly With Two Seal Units Product No. 443-E2
Baker Model "D" Retainer Production Packer Product No. 415-D
Baker Type "E" Full Opening Non-perforated Production Tube Product No. 457-E

Permits removal of either string independently of the other, however long string must be run first. Short string pulled first. Full-Opening (Tubing I.D.) Long String.

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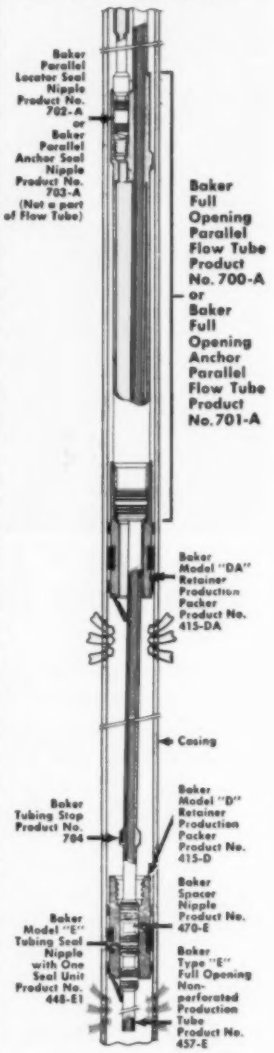
Baker Parallel Locator Seal Nipple Product No. 702-A
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Baker Parallel Anchor Seal Nipple Product No. 703-A
(Not a part of Flow Tube)
Baker Full Opening Parallel Flow Tube Product No. 700-A
or
Baker Full Opening Anchor Parallel Flow Tube Product No. 701-A
Baker Model "DA" Retainer Production Packer Product No. 415-DA
Casing
Baker Tubing Stop Product No. 704
Baker Model "D" Retainer Production Packer Product No. 415-D
Baker Spacer Nipple Product No. 470-E
Baker Model "E" Tubing Seal Nipple with One Seal Unit Product No. 448-E1
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Illustrates Two-Packer parallel string installation with each zone confined to its individual tubing string with full-opening to lower zone for use of all permanent-type completion tools.

Natural Dilution Lifting . . .

A New Method of Producing Viscous Crudes

Napoleon Lista,
Socony Mobil de Venezuela, Caracas, Venezuela

In Eastern Venezuela, heavy crude reservoirs underlie medium and light gravity zones. Socony Mobil de Venezuela devised a dual completion that permits mixing so viscous crude could be produced under normal flowing conditions

A NEW PRODUCTION METHOD, called natural dilution lifting, has been developed by Socony Mobil de Venezuela in the Guico area of Central Anzoategui in Eastern Venezuela. This new idea has proved to be an economical and convenient method to produce heavy, viscous crude oil as well as to offer the advantages of dual completions. Excess energy that otherwise would be dissipated in the natural flowing production of light crude was utilized to great advantage. Light crude from one zone was mixed in the tubing string with heavy oil from a second zone. Although a blend is produced, the two zones remain entirely separated with no possibility of contamination. Control of the light oil reservoir is possible at all times because it can be tested separately and pressure surveys can be run when necessary.

Equipment used in this type completion is standard for single permanent-type completions. Steps have been devised to facilitate wireline work, despite the fact that wireline tools will not fall through the heavy oil. Natural dilution lifting has been credited, to the end of August 1957, with over 240,000 bbl of 12.2 deg API gravity oil production, which was produced at little added expense over the usual cost of oil flowing naturally. Production from the light oil zones compares favorably with the production rates from similar zones which are not being utilized as diluents.

Oil Reservoirs in Eastern Venezuela

Among the many oil reservoirs encountered in Eastern Venezuela, it is a common occurrence to find heavy oil underlying light and medium gravity reservoirs. The high viscosity of the heavy crudes makes production from the reservoirs practically impossible with the facilities presently available in most fields.

Transportation and treating of the heavy oil after it is brought to the surface add greatly to the difficulties of producing it. When both light and heavy prospective completion zones are found in a well, a probable decision

FIG. 1. **Heavy crude production** in the Guico area of Central Anzoategui is in the North Oscurote field.

for the operator would be to delay production from the heavy oil sands until reservoirs containing lighter crudes were depleted. If this reasoning is followed the problem of transporting the heavy oil becomes a very difficult one. Viscosity of the heavy oil (see Table 1) is such that dilution with lighter oil before it is delivered to the pipeline is essential.

Depletion of light to medium gravity oil reserves prior to initiation of production from the heavy oil sands would of course preclude utilization of this relatively simple solution of the problem of transporting heavy crudes.

Mixtures of light oil from the I-4,5 sand and heavy oil from the T-1,2, sand of the North Oscurote field (for location see Fig. 1) were found to have gravities and viscosities shown in Table 1.

It seemed that the oil companies operating in the area had no other alternative to leaving the oil in the ground than to produce it by one of the relatively expensive methods previously used. Heavy pumping installations and subsequent dilution of the produced crude, hollow sucker rod strings to effect down-the-hole dilution, pumping oil under pressure to dilute and lift the heavy oil, and high-pressure gas lifting and subsequent dilution were some of the methods proposed.

Viscous crude problems. Le Bourgeois summarizes[1] the difficulties of heavy oil production at Richmond's Boscan field in Western Venezuela where to pump 10 deg API gravity crude, pumping units rated at 35,000 lb load and 912,000 in.-lb peak torque are used. The units pump at 10-12 strokes per minute on 100 to 120-in. stroke. High friction losses necessitated the laying of 6, 8, and 10-in. flowlines. The crude does not flow at ambient temperature, so the oil must be heated to be transported. To minimize heat loss, the lines are insulated with fiber glass and buried.

Consideration of the facilities customarily available for producing and transporting oil from Eastern Venezuelan fields shows that this method of heavy oil production would be highly expensive. Even if there were enough light oil for dilution to overcome transportation difficulties, the high cost of pumping installations, large diameter flowlines and maintenance would remain.

Napoleon Lista, *a native of Venezuela, is a data processing engineer for Socony Mobil de Venezuela producing group in Caracas, Venezuela. After attending McGill University in Montreal, Canada, he worked for Venezuelan Atlantic Refining Company where he was in charge of the Petroleum Engineering Laboratory in Tucupida. He then worked as a field petroleum engineer in Socony Mobil de Venezuela's Eastern Venezuela fields prior to his present assignment.*

All of these methods practically preclude dual-zone completion if the well is a heavy oil producer, and if they were employed would necessitate the drilling of additional wells for completion in light oil sands. An optimum solution would be one allowing production of the heavy oil at costs comparable to those of producing lighter oils and with no particular treating or transporting difficulties. The task was to produce the heavy crude economically and without delaying production from the lighter oil reservoirs. It was found that when certain conditions were fulfilled heavy oil sands in the area could be produced without special or expensive equipment or undue difficulties and without delaying production from the light to medium gravity oil reservoirs, and at costs comparable with those of the lighter flowing production.

Natural Dilution Lifting

Natural dilution lifting was developed as an answer to the problem. This production method uses the excess energy from light oil zones to help lift the heavy crude and at the same time effecting down-the-hole mixing to produce a medium-gravity blend which would compare with some of the crudes flowing naturally in the area. The relative proportions of mixing crudes can be varied to change the composition and properties of the blend. Excellent flowing characteristics of some of the light oil sands, and the presence of deeper reservoirs with enough bottom-hole pressure to bring the heavy crudes to the surface and in some cases flow a limited volume seemed to assure good results for this proposed new production method. Accordingly, it was decided to equip a well to produce by natural dilution lifting and to develop practical solutions to such production problems as may be encountered. The added expenditure was so small in comparison with the possible returns that "learning-by-doing" appeared to be a good approach.

Trial and error testing. The original proposal called for determination of the flowing characteristics of both zones, use of the light oil zone to dilute and lift production from the lower zone, and dually completing the well with three sliding sleeve valves in the tubing string and a landing nipple to be positioned below the bottom sleeve. Position of the valves in the tubing string was to be determined from data obtained during testing the sands. The well was to be brought in by swabbing the tubing with one of the valves open. The landing nipple was added to make production from the upper zone through the tubing possible if at any time it was desired to produce the well as a single zone. If the heavy-oil fraction was too low, the open sleeve could be closed and one valve lower in the string could be opened. If it was too high, a sleeve higher up the string could be opened.

Mandrels and Valves

Sliding sleeve mandrels proved to be a poor choice, since any device allowing two-way flow was found impractical. If at any time the pressure of the tubing zone at the point of communication exceeded the annular pressure, the casing would be loaded with heavy crude, thereby killing the zone. A displacing job was required with resultant lost production and added expenditure.

The light oil zone could not be tested without the use of a wirelike service to close the open sleeve and to re-open it after the test was completed. Water production could cause scale deposi-

TABLE 1. Proportionate Blends of Light and Heavy Oils and Resulting Gravities and Viscosities.

	I-4, 5 %	T-1, 2 %	Clean gravity (Hydrometer)	Viscosity 100 F	130 F	170 F	210 F
A	100	—	32.7 at 60/60 F	48SSU	42SSU	38SSU	35SSU
B	90	10	29.4 at 60/60 F	65	51	42	38
C	80	20	27.2 at 60/60 F	90	62	48	42
D	70	30	25.5 at 60/60 F	161	94	60	46
E	60	40	22.6 at 60/60 F	265	138	77	53
F	50	50	20.4 at 60/60 F	569	262	123	74
G	40	60	18.1 at 60/60 F	1714	669	265	124
H	30	70	15.5 at 60/60 F	4780	1665	514	235
I	20	80	14.0 at 60/60 F	12982	4323	1100	388

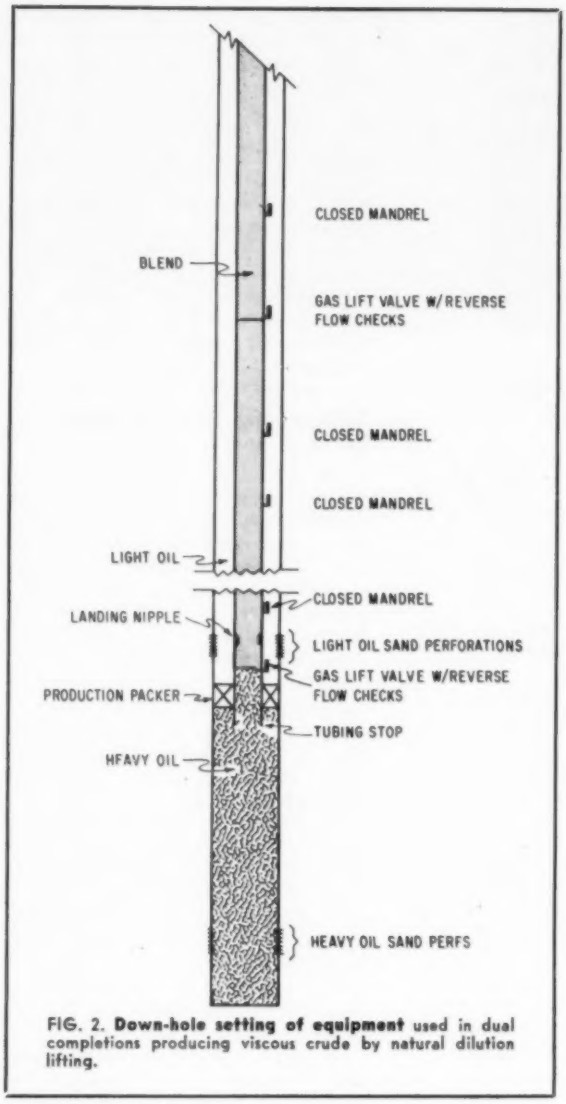


FIG. 2. **Down-hole setting of equipment** used in dual completions producing viscous crude by natural dilution lifting.

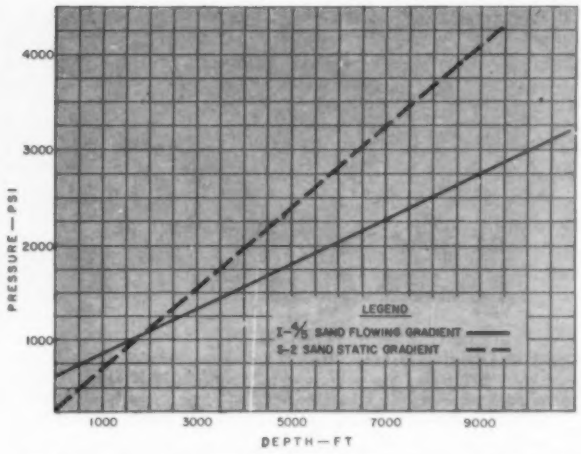


FIG. 3. **Pressure equilibrium** in Well C was determined by the intersection of the flowing gradient pressure of the light oil and the static pressure gradient of the heavy oil.

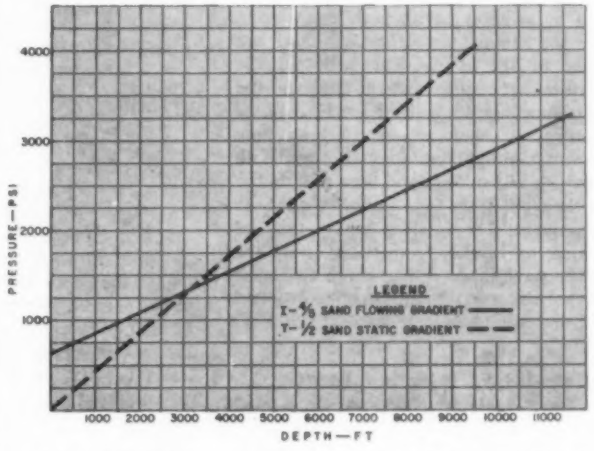


FIG. 4. **Point of pressure equilibrium** in Well D for natural dilution lifting is the intersection of the flowing pressure gradient of light oil and the static gradient of the heavy oil.

tion which would hamper operation of the sleeve and repeated opening and closing could tear the packing elements.

A schematic diagram of a well equipped to produce by natural diluent lifting is shown in Fig. 2. Among the available equipment, circulating valves with reverse flow checks offered a better solution. Flow is possible only from the casing annulus into the tubing. To test the light oil zone it is sufficient to close the tubing and open the casing, and reverse the procedure at the end of the test to resume mixed production. The well can be produced as a single zone following the same procedure as for testing.

Side pocket-type gas lift mandrels were selected for use in wells equipped for natural dilution lifting. At first, double-check reverse-flow circulating valves were used in the side pocket mandrels at the point of injection. Use of these check valves has been discontinued and orifice valves are now used. If the light oil casing zone is overproduced at a particular point of injection, the orifice size can be reduced by pulling the valve, and changing the orifice. A reduction in orifice size restricts the flow from the casing and allows the percentage of heavy oil production to be maintained at satisfactory level. Without this form of flexibility it would be necessary to move the point of injection to a lower mandrel. Mandrel spacing may be such that moving the point of injection would result in an excessive heavy oil fraction and subsequent discontinuance of flow.

In regard to installation, the tubing string can be run with orifice valves in one or two mandrels near the calculated point of initial injections and dummy valves in the remaining mandrels. A wireline tripping and closing tool is used to operate the orifice valves upon selecting the desired point of injection.

The Landing Nipple

In the original proposal it was planned to place a landing nipple below the bottom sleeve for the purpose of blanking-off production from the heavy oil zone when it became advisable. The high viscosity of this crude prevented wireline tools from falling through it, and this led to the conclusion that some means of displacing the heavy crude to a point below the landing nipple had to be incorporated in the string.

Pumping the tar back into the formation might require excessive

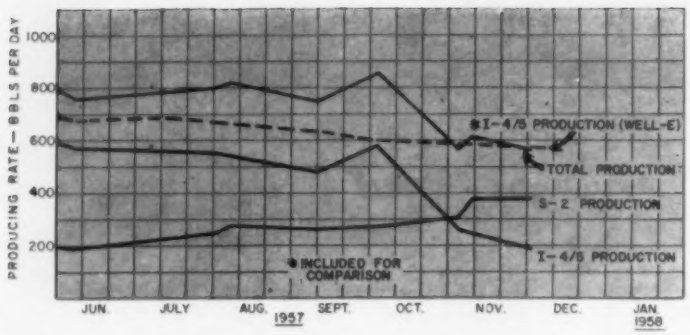


FIG. 5. **Production history, Well C** for natural dilution lifting. Light oil zone I-4, 5 from 9564-9570 ft and heavy oil zone S-2 from 10,619-10,635 ft. Conventional production of light oil from Well E (dotted line) included for comparison only.

pressures so it was decided to add a circulating valve with reverse flow checks below the landing nipple.

After the first well was equipped for natural dilution lifting, it was found that it was impossible to bring the well in by swabbing with both zones open in the tubing, since the tar would rise and fill the tubing. This problem was solved by setting a blank choke in the landing nipple with the well full of water or light oil, establishing flow from the light oil zone through both casing and tubing, and then pulling the blank choke to let the heavy oil zone come in. The landing nipple may be used to choke production from the heavy oil sand, and to serve as a stop for tools or valves that may be dropped in the tubing.

Calculating Injection Point

Provided sufficient data can be obtained, the point at which pressure in the flowing column of fluid from the upper zone is equal to that from the lower zone may be calculated as follows:

Let:

P_1 = Flowing bhp of the lower zone at the desired producing rate (psig at midpoint of perforation).

P_2 = Flowing bhp of upper zone (psig at midpoint of perforations).

P_3 = Pressure at point "x," in the flowing columns of fluid above the upper perforations (psig).

a = Distance between midpoints of perforations of upper and lower zones (ft).

b = Distance between midpoint of upper perforations and the point "x" at which the flowing pressure in the upper zone (casing) equals the flowing pressure in the lower zone, (ft).

r = Flowing pressure gradient upper zone (psi/ft).

s = Flowing pressure gradient lower zone (psi/ft).

Then:

$$P_3 = P_1 - s\,(a + b) = P_2 - r\,b$$

And,

$$b = \frac{P_1 - P_2 - s\,a}{s - r}$$

"x" in ft sub-rotary is of course equivalent to the depth to the midpoint of the upper perforations minus b.
Utilizing data approximated for well D, "b" may be calculated as follows:
Zone I – 4,5:

Perf. Int. 9545 – 9556 ft.
Zone T – 1,2:

Perf. Int. 10,686 – 10,708 ft.

$P_2 = 2810$ psig

$P_1 = 4000$ psig

$$b = \frac{4000 - 2810 - 0.355\,(1147)}{0.355 - 0.230}$$

$$b = \frac{400 - 2810 - 407}{0.125}$$

$$b = \frac{783}{0.125} = 6260 \text{ ft}$$

$a = 1147$ ft

$r = 0.230$ psi/ft

$s = 0.355$ psi/ft

Since "b" is the distance from the midpoint of the upper perforations to the point of equilibrium "x," the sub-rotary distance to "x" is 9550 – 6260 ft, or 3290.

It is customary to obtain data needed above on the upper zone while drill-stem testing. For the lower zone, it is seldom possible to run a bottom-hole pressure bomb on a wire line through heavy oil and obtain accurate static and flowing pressures; however, the pressure recorder run in conjunction with the tester will provide useful data, which in conjunction with pressure-volume-temperature information on similar crudes (reservoir fluid gradients) permit an attempt to determine the equilibrium point utilizing the above formula. A fluid level measuring device would provide additional useful data on the lower zone.

Determining Injection Points, Wells C and D

The lack of information available at the time these wells were completed forced the application of another method for determination of the injection point. The approximate point of pressure equilibrium was taken as the intersection of the graphs of depth versus flowing pressure of the light oil and depth versus static pressure of the heavy oil. Any reduction in pressure of the heavy oil sand caused by flow was assumed to balance pressure loss of the light oil due to added friction in the casing and pressure drop through the valve orifice.

The point of injection for maximum lifting efficiency is somewhere above the point of pressure equilibrium. Fig. 3 and 4 are graphical determinations of the point of pressure equilibrium for wells C and D. After the point of injection is determined the valves are spaced at 500 to 700-ft intervals depending on the gravity and the viscosity of the heavy oil.

Application of this method has given such encouraging results that it is believed it can be applied successfully in most cases. The two trial wells substantiated results obtained from calculations. The point of pressure equilibrium, as read from the graph, for Well C was about 1800 ft. The well was completed producing through the top mandrel at 1500 ft. While completing and testing the well, the circulating valve was set in the mandrel at 2300 ft but the well made 100 percent heavy oil. On the other hand, the point of pressure equilibrium for Well D was found to be at 3100 ft. The well is producing through the mandrel at about 2600 ft. While testing, the circulating valve was placed in the top mandrel at 1500 ft and the well flowed 100 percent light oil.

Equipment and Procedure

The following installations were made in two wells in the North Oscurote field:

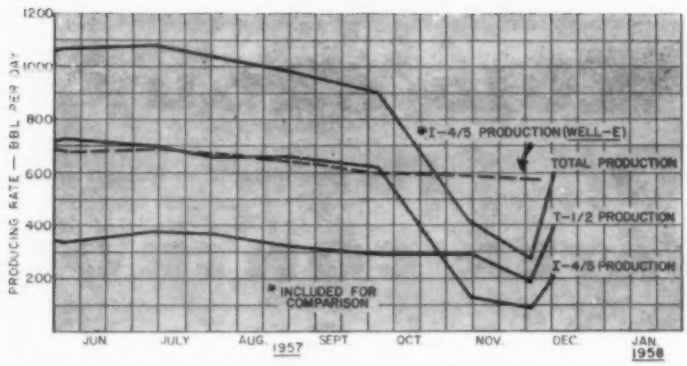


FIG. 6. **Natural dilution lifting, Well D,** showing production history. Heavy oil zone T-1, 2 from 10,686-10,708 ft and light oil zone I-4, 5 from 9545-9556 ft. Light oil production from Well E (dotted line) by conventional flow is included for comparison only.

Well C

Mandrels	Depth of Mandrel	Equipped with
1	6600′	Valve w/checks
2	6400′	Dummy
3	4500′	Dummy
4	4000′	Dummy
5	3500′	Dummy
6	2900′	Dummy
7	2300′	Dummy
8	1500′	Valve w/checks

Landing nipple at 6200 ft. Production packer at 9700 ft.

Well D

Mandrels	Depth of Mandrel	Equipped with
1	6594′	Valve w/checks
2	6402′	Dummy
3	4796′	Dummy
4	4204′	Dummy
5	3509′	Dummy
6	2591′	Valve w/checks
7	1504′	Dummy

Landing nipple at 6500 ft. Production packer at 9650 ft.

To facilitate wireline work, the well should be kept full of salt water rather than mud in all cases where it is safe to do so. The production packer should be set close to the upper zone to reduce through-tubing friction. The tubing string with mandrels spaced as indicated above should be run. One mandrel should be placed a short distance above the packer and another about 200 ft above the bottom one with the landing nipple half-way between the two.

Dummies should be run in all mandrels other than the bottom one. Valves in the closed position can be run in place of dummies. A circulating valve with reverse-flow checks should be run in the bottom mandrel, and the following procedure followed.

Installing equipment. Set a blank choke in the landing nipple. Pull the dummy from the mandrel immediately above the landing nipple. Swab the casing zone until flow is established (on the wells mentioned in this report, it has taken from 7 to 23 hours to establish flow in the annulus after the well started to flow through the tubing).

Reset dummy in open mandrel and replace dummy in mandrel nearest the calculated point of injection with a circulating valve or orifice valve. Pull the blank choke. Put the well on production by permitting the light oil to dilute and lift the heavy oil.

If the heavy oil fraction is too high, move the point of injection up, if it is too low, move the point of injection down. If moving up or down causes too much of an effect, then the use of orifice valves is indicated. The required orifice size must be determined experimentally.

Production by Natural Diluent Lifting

Fig. 5 and 6 illustrate the production history of Wells C and D. Gas-oil ratios have been low and are not included. For purposes of comparison, the production curve for the I-4,5 sand of Well E, a zone flowing conventionally is also plotted in the same figures. Light oil production from the natural diluent completions is quite similar to that of Well E except for the later months when it was decided to increase the proportion of heavy oil from Wells C and D by moving the point of mixing or by changing orifices. Results were considered successful since heavy oil production was increased by 100 bbl per day for each of the two completions. To January 1, 1958, over 240,000 bbl of 12.2 deg API gravity crude have been produced by Wells C and D, which continue to produce satisfactorily.

Oil produced is allocated to the two zones on the basis of gravity determinations made throughout the test, and calculated from the formula:

$$(x)\ SG_h + (1 - x)\ SG_L = SG_b$$

Where: SG_h, SG_L, SG_b are the specific gravities of the heavy fraction, light fraction and blend respectively.

x is the fraction of heavy oil in the blend.

Calculating production allocation. To illustrate the above discussion, consider the case of a well producing 558 bbl per day of 26.5 deg API gravity mixed crude with a total GOR of 451 std cu ft per bbl. Gravity of the heavy oil is 12.0 deg and that of the light oil 31.0 deg. Tested by itself, the light oil zone produced with a GOR of 550 std cu ft per bbl. Calculation of production allocation is as follows:

$12°$ API $= 0.9861$ Sp. Gr. $= SG_h$

$31°$ API $= 0.8708$ Sp. Gr. $= SG_L$

$26.5°$ API $= 0.8956$ Sp. Gr. $= SG_b$

$(x)\ SG_h + (1 - x)\ SG_L = SG_b$

$0.9861 \times 0.8708\ (1 - x) = 0.8956$

$0.1153\ x = 0.0248$

$x = 0.215$

Thus 21.5 percent of the total production is heavy oil for a daily rate of:

$558 \times .215 = 120$ B/D heavy crude

and $558 - 120 = 438$ B/D light production.

Gas allocated to the light oil zone would be:

438 B/D $\times 550$ cu ft/bbl $= 241{,}000$ cu ft per day

Gas allocated to the heavy oil fraction would be the total gas produced minus the gas allocated to the light oil zone, or

$(558 \times 451) - 241 = 251 - 241$
$= 10{,}000$ cu ft per day,

and the heavy oil zone GOR:

$$\frac{10}{120}$$

$= 83$ std cu ft per bbl.

To facilitate field allocation of production, graphs of the heavy oil fraction versus gravity of the produced blend have been made. Gas is allocated by testing the light oil zone separately and using the measured GOR to obtain by difference the gas produced from the heavy oil zone.

Acknowledgment

Permission granted by the Socony Mobil Oil Company de Venezuela to publish this report is hereby acknowledged. The author wishes to thank all members of that company whose assistance made this report possible.

Reference

1. "Producing Viscous Fluids," by Guy Lebourgeois, *Journal of Petroleum Technology*, May 1957.

★ ★ ★

Lab and field tests promising

FLUID GROUT for WATER CONTROL

Polymeric water gel suggests solution to water intrusion problems in air drilling, water influx in producing wells. Applications also seen in sealing thief zones in secondary recovery injections, stabilizing soil conditions around mine shafts, dams and tunnels

Wayne Hower **Charles McLaughlin**
Joe Ramos **John Land**
Halliburton Oil Well Cementing Company, Duncan, Oklahoma

THE USE OF AIR, gas and aerated mud as the circulating media in drilling for oil and gas has drawn considerable attention from the oil industry. Papers, too numerous to mention, have been written on the various phases of this type of drilling. In some instances, a particular experience was described in detail while, in others, a highly technical presentation has been made. All of these papers have contributed important information and most of them have emphasized the savings in time and dollars that can be made possible by using air. (For simplicity, the term "air" will be used when referring to air, gas, and aerated mud drilling.) Drilling rates were increased, bits lasted much longer, and the cost of drilling a well was much lower than when conventional muds were used. However, as it frequently is with anything new, there is usually one significant deterrent that develops with a new technique. In this case, water producing zones proved to be the biggest and most persistent trouble.

Water production has caused trouble in different ways. Seeping or weeping zones that produce small volumes of water are particularly bothersome. The cuttings become wet enough to stick together and frequently collect on the sides of the hole. The resulting slim hole has been known to stick the bit when a round trip is attempted. There have been a few cases reported where the raising and lowering of the bit has dried up such a zone. It is thought that this procedure muds off the offending horizon.

Zones that produce moderate flows of water can be handled without too much trouble in some areas. However, an accumulation of several of these zones can overload the hole with water. In addition, where certain shales drilled very easily and to size when the hole was dry, a rapid filling of the hole with expanded shale was obtained when water was encountered.

Shutting off water in a producing well is one problem — shutting off various types of water flows in an air drilled well is another. Water control in oil wells has been successful through the media of several materials, all of them meeting with some success. An air drilled well is unique in that it has no casing to help support a plugging material in place; furthermore, the agent cannot be allowed to reduce hole size and at the same time must be able to withstand the continual beating of the drill pipe.

To combat water flow in both producing and air drilled wells, a research program was initiated to develop materials and techniques designed specifically for this purpose. Where water is being produced from the true permeability of a zone, it was deemed advisable to work with true solutions that eventually stiffen or harden so that effective penetration of the formation would be obtained. This type of grouting solution will also help to prevent any permanent decrease in hole size.

FIG. 1. **Rig used in drilling wells** to test materials for shutting off water. The air-water separator in the water measuring system is shown at the right of the illustration.

Where water is being produced from inherent fractures, a grouting fluid containing solids was thought to be applicable. After a considerable amount of investigation, specifications were developed to describe the ideal grouting solution. They are:

1. Low viscosity — preferably that of water.
2. Good viscosity control. That is, the viscosity of the solution should remain low until a positive setting action starts. This

This paper was presented under the title "Water Control A Possibility With New Grouting Fluid," at the Spring meeting of the Eastern district meeting of the API Division of Production, Columbus, Ohio, May 7-9, 1958.

permits a longer effective time to place the solution.

3. Controlled set. Must be reliable in its setting characteristics and to save rig time, must set in a reasonable period.
4. Set must be either a stiff gel or hard.
5. Must be economical for the existing conditions.

Many true solutions were so investigated. Representative cores from several areas were saturated with water and then treated with these solutions to give a good plugging action. These results were obtained both with grouting solutions that polymerized to form a hard set and solutions that form stiff gels. In many instances, cores one inch long that were treated with a solution that set to produce a stiff gel were able to resist hydraulic pressures up to 2000 psi.

Efforts were made to apply some of these materials under field conditions but this type of research proved to be very slow. To hasten the program, the small rotary rig shown in Fig. 1 was purchased. The system was adapted to air drilling with a 315 cu ft per min air compressor having a maximum working pressure of 120 psi. These specifications are much lower than normal field usage but they proved adequate for our relatively shallow wells. In every well, the shallower water zones were cased off with 5½-in. 14 lb casing. After drilling out, the cement job was tested before making additional hole. Most of the water producing zones were encountered between 300 and 560 ft and were easily detected by the loss of dust returns and then by the production of water at the surface. All of these formations were cored using a 4¾-in. by 10-ft core barrel with about 50 percent recovery. The water producing formations were usually not more than 20 ft in thickness and consisted mainly of soft to fairly well consolidated sand sometimes interbedded with red bed type of shale. Water production ranged from 6 to 50 gal per min. The permeability of the recovered cores varied between 0.5 millidarcies to 5400 millidarcies.

One particular horizon showed a permeability range of 0.3 millidarcies to 7.8 millidarcies and an average porosity of 27 percent. However, it was impossible to pump water into this formation at less than fracturing pressures which prevented any type of treatment aimed at shutting off the water flow. Subsequent laboratory research with the samples from this formation proved that it was impossible to force water through the cores at any pressure up to 100 psi. It was found that the relatively soft sand would crush at the pressure

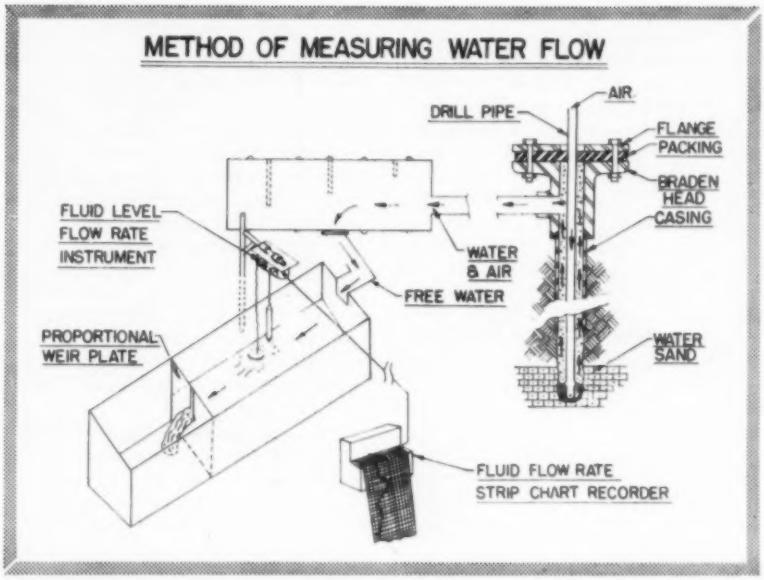


FIG. 2. **Schematic diagram of water separating system** and calibrated weir plate used to determine the water flow rate in the air-drilled wells. Flow rate was calculated in gallons per minute.

side of the core face. The loose particles were then forced into flow channel openings which caused a drastic reduction in the flow capacity of the core. Other factors that could contribute to very low or zero injection rates are the deformation of the elastic rock to decrease diameters of flow channels, clay colloids in the water and the fact that a tremendous volume of water must be displaced in a saturated reservoir to make room for the sealing solution.

Flow Rate Measurement

For controlled research in the test well, it was found necessary to devise an accurate method to determine the flow rate of each water producing zone. The schematic diagram shown in Fig. 2 describes a gathering and separating system that routes all produced water to a sump. The flow out of the sump through a calibrated weir gives an accurate and quick method of determining water flows and greatly aided in the evaluation of the many sealing materials that were applied to the five wells that were drilled for this purpose.

The correct placement of the sealing solutions proved to be one of the most important phases of the entire procedure. Past experience has shown that it is possible for the sealing material or the displacement fluid to enter barren formations or shale bodies which prevents the successful placement of the grouting fluid.

For this reason, applications in the test wells were performed under a packer so that the materials could be exactly placed. The presence of heaving shale above the zone being treated greatly complicates finding a packer seat and removing the packer from the hole, but experience has shown that the proper isolation of the zone being treated is greatly desired and should be done whenever possible. One packer used for this work is a modified retrievable tool equipped with mechanical support slips with enough horizontal over-travel to permit engagement in enlarged holes. This system is familiarly known as a side wall anchor and has been used extensively for off-bottom drillstem testing. The packing element is a rubber sleeve of the expanding shoe type. To help prevent unseating of the packer with excessive pressure differentials, a hydraulic hold down device is incorporated in the tool.

Once the zone is isolated, the main problem is to place some of the grouting solution in all parts of the water bearing zone. To obtain this successful application, it is believed that a fracture must not occur during the pumping operation. If one should occur, the grouting solution will probably follow the fracture and not saturate all of the water bearing zone. In most instances, it is not possible to determine at what pressure any given formation will fracture. This fact alone certainly complicates the placement problem.

After a water zone was encountered in the test wells, an analysis of the cores was made. The treating procedure was thoroughly planned, and, under controlled conditions, many chemical solutions were applied which led to a comprehensive evaluation of each fluid and a much better understanding of the problem.

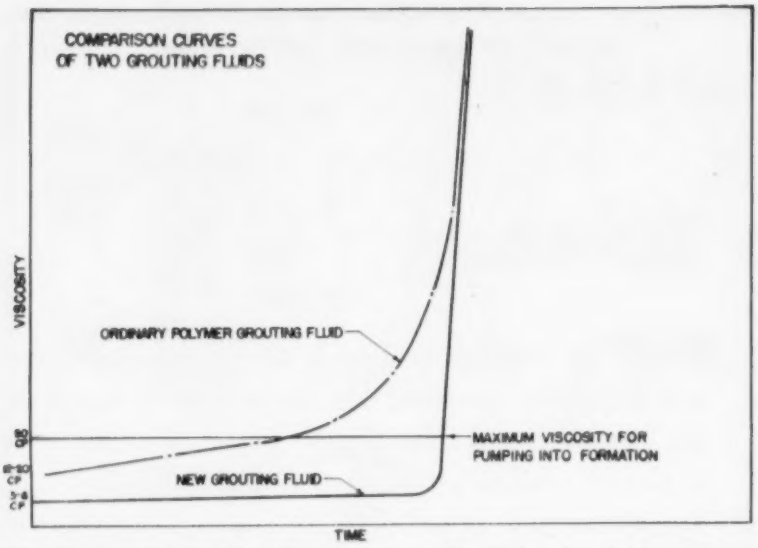
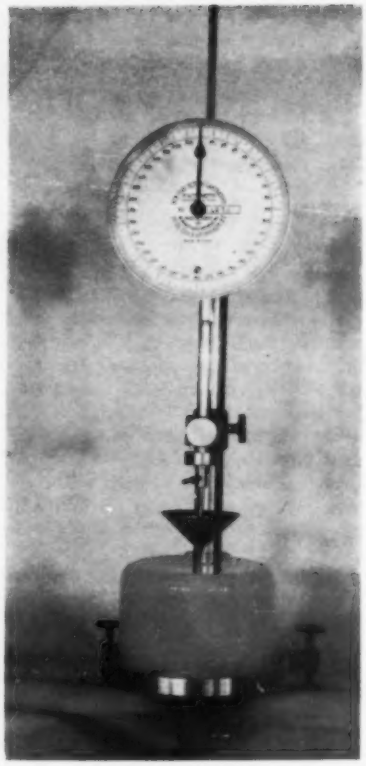


FIG. 3. **Comparative time-viscosity curves** of conventional polymeric materials and the new grouting fluid. The sustained low viscosity of the new fluid is highly desirable when grouting low permeability formations.



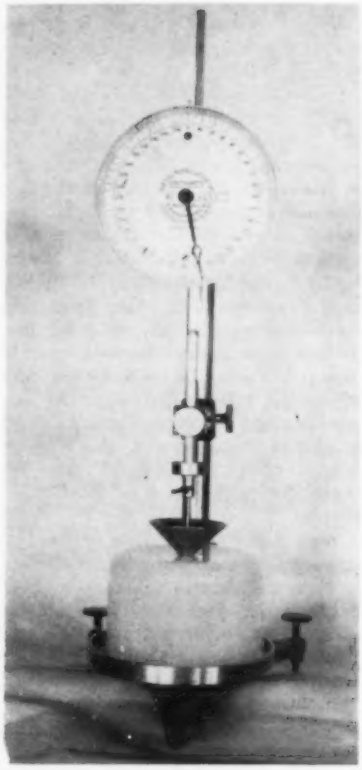


FIG. 4. **Unsupported polymeric water gel** is shown shortly after it has set. The lower picture illustrates the limited penetration of the heavy cone into the stiff gel.

Cleaning and Testing

The first step in the treating procedure was to blow the well long enough to clean the hole of all cuttings and obtain a steady water flow rate. The next step consisted of pumping water into the producing formation to determine the rate at which the treating fluid could be displaced. It had been noticed previously that it was often difficult to pump into these formations at an appreciable sustained rate. A test was made to determine the effect of blowing the hole on the injection rate into the formation. A formation 13 ft thick, that was producing 17.5 gal of water per min, was pumped into with water and the rates recorded. After blowing the well for four hours, a three centipoise grouting solution was spotted, the packer closed and then displaced into the formation. The comparative pumping rates were:

Volume pumped, bbl	Pumping Rate (Bbl per Min) Before blowing	After blowing
1	0.5	0.5
1.5	0.3	0.5
2.0	0.16	0.5
3.0	Discontinued	0.4
3.5	——	0.3

The technique of blowing the hole with the packer tool on the drillstem was adopted so that injection could begin immediately after cleaning the hole for the desired time.

Polymeric Water Gel

Of the many chemical solutions applied, one particular solution appeared to give better results and have more desirable properties than the rest. The grouting solution, a polymeric water gel (PWG), has a viscosity of about three centipoises which remains in this viscosity region until it starts to set. For simplicity, this material will be hereafter referred to as PWG. Fig. 3 is a representative time-viscosity relationship of the PWG solution. Also shown is a typical curve usually found for most resins. This viscosity characteristic is of great value as the solution remains in an excellent pumping and penetrating condition for about 95 percent of its fluid life. The set PWG is a very stiff gel which is shown in Fig. 4. Another advantage is the fact that maximum stiffness is obtained within 15 minutes after the solution starts to set, which greatly reduces the rig time required for the complete treatment. The setting of PWG is temperature sensitive. Therefore, for maximum reduction of rig time, an accurate formation temperature is required so that the proper formula can be mixed for the treatment.

Although PWG does not set hard, the stiff gel has sufficient strength when placed in a porous medium to hold back considerable pressure. A column 3 in. long and 2 in. in diameter was packed with unconsolidated 40 to 60 mesh sand and then saturated with PWG. A one inch diameter ring was placed at the bottom of the chamber. After the solution had set, it required 2500 psi to extrude the consolidated sand as a one inch diameter cylinder.

Since it has been emphasized that a packer of some type should be used to isolate the water bearing zone during treatment, it was deemed necessary as part of the research program, to determine if such a set material would stick the packer in the hole. During

one treatment, enough solution was pumped on top of the packer to fill 30 ft of annular space, the packer set, and the formation treated under the packer. After the material had set, the packer was unseated and pulled out of the gel with very little difficulty. Set PWG in the drill pipe was pumped out a stand at a time without difficulty.

The PWG solution can be diluted up to 25 percent by water in the hole without losing any appreciable strength in the set product. A slight loss in strength is noticed at 50 percent dilution and a set product of good strength is still obtained when 100 percent dilution is noted. The dilution safety factor for field applications plus the very doubtful possibility of ever sticking a packer makes the solution very attractive.

Three zones were successfully treated in the test wells. One 13 ft zone was treated with 210 gal of PWG to shut off 17.5 gal of water per min. A zone of 10 ft was treated with 210 gal to shut off 31.5 gal of water per min. The last zone of 10 ft was treated with 210 gal to shut off 20 gal of water per min. After additional treatments with another material at greater depths and side wall coring of the treated formations, water production still remained at zero.

PWG Field Applications

Successful field applications have been made in the Fort Stockton area in West Texas. One 30 ft zone making 12 bbl of water an hour was completely shut off with 600 gal of PWG. Another zone of 20 ft making 9 bbl an hour was reduced to three barrels an hour. A second treatment completely stopped the flow of water. The two treatments on this zone were made in 80 ft of open hole with no packer set in the formation.

As this hole was deepened, additional water was found in three zones covering 90 ft of formation at 200 ft below the casing. The bradenhead squeeze treatments in this amount of open hole were not too satisfactory. It required five applications to reduce the flow of water from 50 bbl an hour to essentially zero. It is strongly felt that this last horizon could have been sealed with two applications if a packer had been allowed in the hole. However, valuable information was gained from these bradenhead squeezes. It was found that it took an unusually long time to dry up the well or obtain a steady water flow rate after a squeeze.

It is strongly believed that unproductive horizons will accept a certain amount of fluid under pressure. Since there is no formation pressure available to rapidly discharge this fluid after the hydrostatic pressure in the hole has been removed, the fluid will gradually bleed back into the hole over a relatively long period of time. Thus, it is difficult to quickly determine the true condition of the treated water bearing formation. Another source of water is condensed water from air compressors. Water production in one instance was reduced one quart a minute when the sun came up and warmed the air. Water of this type would probably not be noticed in a dry hole but where the entire hole has been in contact with water for sometime, essentially all of the water condensed in the air stream returns to the surface. This information strengthens the argument for isolating the water zone with the proper packer assembly.

Extended Applications

Applications of the polymeric water gel are now being contemplated in producing and water injection wells to control the flow of water. It has long been believed that a more efficient shut off of water in producing wells could be obtained if a true fluid could be pumped into the water bearing formation that would set to form a permeability block to the flow of water. The multitude of cement slurries that have been used for controlling water have performed at different degrees of efficiency and their value has been proved many times. But, their blocking action is due only to solid type plugs in perforations or a horizontal fracture close to the oil-water interface. Therefore, a true permeability block in the producing formation that penetrates to a distance away from the well bore should be more efficient. The main problem in such a treatment would be the proper placement of the PWG solution. Set PWG is not soluble in any well fluid or any other conventional chemical solution which emphasizes the point of not treating too much of the oil zone. Relatively short half life radioactive tracers have been used to exactly spot similar solutions under the same conditions and their use should be applicable in this type of treatment.

Secondary Recovery Uses

One of the more pressing problems in secondary recovery by water-flooding are the thief zones in injection wells that are accepting large percentages of injection water. Surface plugging[1] of these zones has been described and a great deal of benefit has been obtained by such work. Other information[2] has been published which emphasizes the need of sealing these zones to a depth in the formation to prevent by-passing of the surface plug. One of these materials that has been applied successfully for this purpose is a true solution that sets to form a gel somewhat similar to PWG. However, comparative tests show that the PWG is an improved solution, mainly through its ability to be diluted a considerable amount by formation waters and still produce a satisfactory set. Under these conditions, the yield of set product is much greater which gives a more efficient plug in the formation.

Shallow Seeps

There has been a constant demand for materials to grout and stabilize soils in very shallow sub-surface conditions. Consolidation and plugging around mine shafts, dams, tunnels, and subsurface building construction are examples of areas where this type of work is applicable. Cement slurries have been used to an advantage in some instances but the inability of cement to penetrate the true permeability of the soil effects its efficiency. Several true fluids have been successfully applied in certain areas. With some of these, the set of the material is dependent on one solution contacting another solution in the interstices of the formation. Such a system is workable under some conditions but not as efficient as a one phase solution where the entire liquid system will react to form a set product. The polymeric water gel appears to have properties that should be very attractive to shallow fluid grouting operations, and its use has been successful under a variety of conditions.

As stated previously, the original PWG solution can become diluted with formation water and still give a good set. This high yield of set material is very desirable. In addition, the set time of the solution can be varied and controlled to fit local conditions. Solutions having a set time of a very few minutes to several hours can be formulated and a rapid evaluation of the results can be obtained due to the fast accumulation of strength of the set product.

Conclusion

The polymeric water gel, a relatively new material, has unique viscosity-time relationships plus a very fast set once the solution has started to gel. This property makes it attractive not only to oil field applications but to shallow fluid grouting problems. The PWG solution has been applied successfully in the control of water in air drilled wells and in shallow sub-surface conditions. In addition, comparative research with true solutions used previously strongly indicates that the new solution will be more effective in rerouting water in injection wells and controlling water in producing wells.

References

1. Danielson, H. H., and Martin, D., "Selective Plugging in the Bradford Field," T. P. 181, Pennsylvania State College (1950).
2. Hower, W. F., and Ramos, J., "Selective Plugging of Injection Wells by In Situ Reactions," *Journ. Pet. Tech.*, January 1957.

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One of five piercement type salt domes, Cote Blanche Island field is the site of some unusual drilling problems at great depths.

Shell's giant land Rig 11 provided the modern power plant that drilled wells to the deep Miocene sands at Cote Blanche Island.

In the Cote Blanche Island field of coastal Louisiana

New Oil Base Mud Trims Cost and Improves Drilling

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and
G. G. Baker
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In a 2918-ft interval below a long and cased-off salt section, Shell Oil Company (1) cut mud bill by $13.45 per ft, (2) reduced sloughing, and (3) safely landed two liners through hazardous zones

IN 1955, SHELL OIL COMPANY set a record by successfully drilling through a 12,420-ft section of solid salt. This well was the company's Caffery et al No. 1, drilled on the heretofore unproductive north flank of the Cote Blanche Island field, a tilted piercement type salt dome in Saint Mary Parish of coastal Louisiana.

To tap the oil-productive Miocene sands below this salt section, it was necessary to drill from 1826 to 2918 ft deeper. It was this lower section below the cased-off salt section that caused several difficult drilling problems. In addition to the relatively high cost of drilling fluids, sloughing of the hole resulted in sticking the drill pipe and necessitating several costly fishing jobs. Also, it was difficult to run liners to bottom in these sections below protective casing set through the long, deep salt interval.

In an attempt to overcome these problems, Shell Oil Company used a new type oil base drilling fluid in its Caffery et al No. 6 to drill the bottom 2918 ft below the 9⅝-in. casing set at 14,082 ft. Known as Black Magic Supermix this new oil base fluid is a synthetic mud containing a special type air-blown asphalt, mixed with refined oil and a special peptizing agent in combination with a viscosity reducer. For this particular well problem, diesel oil was used for viscosity control and barite was added for weight control. Some lost circulation material was added to prevent loss of the mud into thief zones when employing mud weights over 17 lb per gal.

Although some sloughing did occur until the mud weight was increased to 16.0 lb per gal, no pressure differential sticking[1] of the drill pipe was experienced and there were no fishing jobs. Two liners were run to bottom without difficulty and mud costs were considerably lower than in previous wells.

Total net mud cost on the Caffery et al No. 6, from below the 9⅝-in. casing set at 14,082 ft to 17,000 ft total depth was $47,200, or $16.15 per ft of hole drilled. In a previous well, the Caffery et al No. 5, located 700 ft east of Caffery No. 6, both liners were stuck off bottom, and total mud costs in drilling an 1826-ft interval below the protective casing amounted to $54,000 or $29.60 per ft of hole drilled.

Compared to Caffery No. 5, the No. 6 well resulted in a saving of about $13.45 per ft for a total saving of some

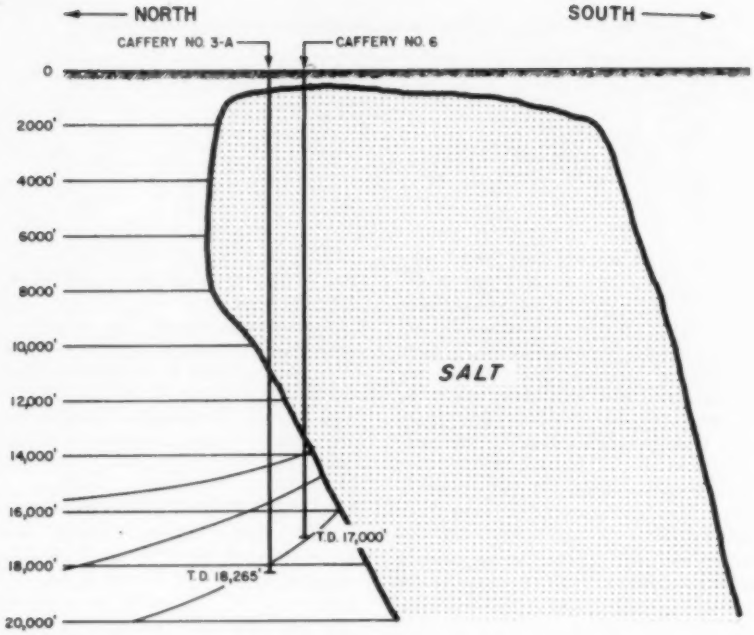


FIG. 1. **Tilted piercement type salt dome** at Cote Blanche Island made it necessary to penetrate nearly 13,000 ft of solid salt to tap the oil-productive Miocene sands on the north flank.

$39,000. The field average for this section below the 9⅝-in. protective casing was $25.30 per ft, or $9.15 per ft more than that of the Caffery No. 6 well.

Area Background

Cote Blanche is one of the five islands that extend northwest from Atchafalaya Bay, as shown on the inset map. To the southeast of Cote Blanche is Belle Island. To the northeast are Weeks Island, Avery Island, and Jefferson Island. Each is a piercement salt dome. Sediments overlying the salt plug have been forced upward, forming islands in the marshes. Some stand 70 to 80 ft above the surrounding swamps.

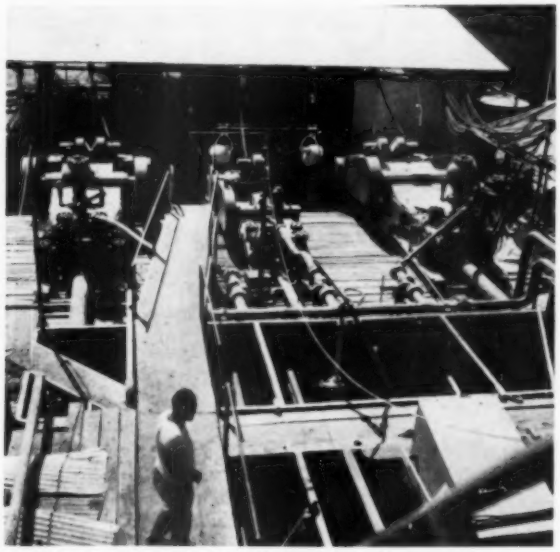
The Cote Blanche Island structure is somewhat unusual in that the entire salt core is tilted in a northerly direction as indicated in Fig. 1. Fifty dry holes were drilled on the south flank before important production was found in 1948. Shell was the first operator to obtain production on the north flank. Caffery No. 1, drilled in 1955, was completed as a gas-distillate discovery with production from the Miocene at 16,410-15 ft. A notable accomplishment in the No. 1 well was drilling 12,420 ft of solid salt — the greatest salt thickness drilled in one hole at that time. Fig. 1 is a generalized cross-section of the Cote Blanche structure.

Drilling Practices and Problems

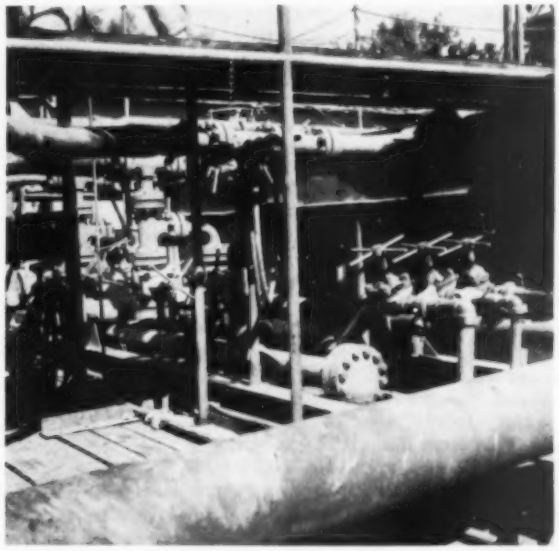
Casing programs. In the six Shell wells, salt was penetrated at 500-1000 ft and was continuous to 11,300-14,200 ft. Casing programs involved setting 20-in. conductor pipe at 120 ft, 13⅜-in. surface pipe at 2000 ft, 9⅝-in. protective pipe at 14,000-14,400 ft (through the salt), and 7-in. and 5-in. liners as required to total depth.

Mud programs. Mud programs in the first five wells involved use of unweighted gel mud to the top of the salt, saturated salt mud from the top of the salt to protective casing depth, and changeover to various types of water-base emulsion muds for the remainder of the hole. The same procedure was used in Caffery No. 6, except the new oil-base mud was used instead of water-base mud below the 9⅝-in. casing in an effort to reduce hole trouble and mud costs.

Drilling problems. Drilling is characterized by lost circulation trouble in the surface hole, general difficulties associated with the use and maintenance of saturated salt muds, and severe sloughing shale in the steeply dipping formations below the base of the salt.



Mud handling section of Shell's land Rig 11. Two main mud pumps and circulating pump, center, take suction from tank in foreground.



Mud manifolding system between pump suctions and discharges with steel mud tanks in background. $1000 was spent on extra rigging to handle oil base mud.

All five of Shell's previous wells experienced severe sloughing and tight hole trouble below the salt.

Three types of mud (salt-saturated oil-emulsion, red oil-emulsion, and lime oil-emulsion) were used in attempts to combat sloughing of shale below the salt overhang. One effective method of controlling sloughing has been to increase the mud weight periodically. Sloughing usually stopped completely when the mud weight reached 15.0-16.0-lb per gal.

However, these high mud weights caused differential sticking which was very troublesome in several wells. It has been proven that when pipe rests against the sides of the borehole, it can become stuck due to horizontal forces pressing the pipe into a thickening mud cake.[1] These forces result from the differential pressure between the borehole and the reservoir and are influenced by the plastering properties of the drilling fluid.

Caffery No. 3-A, the deepest well in the field (18,265 ft), had severe differential sticking with 17.0 lb per gal lime oil-emulsion mud.

Hole trouble was particularly severe in Caffery No. 5, located 700 ft to the east and approximately on strike with Caffery No. 6. In addition to difficulty in making trips and connections, the 7-in. liner stuck 146 ft off bottom and the 5-in. liner stuck 173 ft off bottom in this well.

In Caffery No. 2, the hole sloughed in, stalled the pump, and stuck the pipe at total depth. The pipe was backed off at the safety joint and the fish was not recovered. Completion was effected in a sand above the fish.

Lost circulation difficulties and hole trouble have necessitated setting 7-in. protective liners before reaching total depth in all wells except Caffery No. 2.

Drilling the Caffery No. 6

Casing data:

20-in. @ 120 ft
13⅜-in. @ 1993 ft
9⅝-in. @ 14,082 ft
7-in. liner 13,451-15,592 ft
5-in. liner 15,462-17,000 ft (TD)
7-in. inner string, surface to 13,451 ft.

Program to casing point. The salt was penetrated at 692 ft and was continuous for all practical purposes to 13,605 ft, an interval of 12,913 ft. The mud program mentioned above was followed, with the salt mud being used to 14,082 ft. A 9⅝-in. protective string was landed at this depth. The salt mud system was replaced with the new oil base system before drilling the cement. The oil-base mud was weighted to 10.5 lb per gal and the salt mud displaced in a total of 10 hours. Volume of the circulating system at this point was approximately 1250 bbl.

TABLE 1. Average surface mud properties at various well depths.

Depth	Mud Weight (lb/gal)	Funnel Viscosity	Flowline Temperature	Fluid Loss	Water Content%
14,100	10.5	60	130 F	0	6
14,500	11.6	75	135	0	4
15,000	13.5	110	132	0	4
15,500	14.6	125	130	0	3
16,000	16.1	165	118	0	3
16,500	16.5	175	118	0	3
17,000	17.2	190	115	0	2

Formation and bit data below protective string. As indicated previously, shale formations in this area have been disturbed by intrusion of the salt plug and tend to slough severely. Sand formations adjacent to the dome are mineralized and extremely hard. In general, the shale sections drill fairly fast and the sand intervals extremely slow.

Penetration rates. Direct comparisons between penetration rates with water-base muds used in the other five wells and the oil-base mud used in Caffery No. 6 involve considerable guesswork and arbitrary conclusions due to the differences in amount of hard sand drilled, types of bits employed, mud densities, and variations in bit weights.

In well No. 6, diamond bits were used to drill most of the hard sand formations. Essentially all of the hole below the 7-in. liner was drilled with two diamond bits. Penetration rates varied from as low as 0.85 ft per hr to as high as 8 ft per hr. It is interesting to note that the last diamond bit drilled the final 850 ft at an average of 3.3 ft per hr with only 4000 lb on the bit most of the time.

The 2918 ft of hole from the base of the 9⅝-in. casing to total depth in Caffery No. 6 was drilled at an average rate of 2.12 ft per rotating hour on bottom. In well No. 5, the 1826 ft of hole below the 9⅝-in. casing was drilled at an average rate of 2.16 ft per rotating hour.

Hole temperatures. The maximum temperature recorded in well No. 6 was 250 F at 16,738 ft. Estimated static bottom-hole temperature was 285 F. The normal temperature gradient for this area is approximately 12 F per 1000 ft.

Use of the New Oil Base Mud

The initial oil-base system was weighted to 10.5 lb per gal at the time of changeover (at 14,082 ft), and a total depth of 17,000 ft was reached 99 days later with the mud weight at 17.2 lb per gal. A maximum weight of 17.5 lb per gal was carried for a short period, but was reduced to 17.2 lb per gal due to minor lost circulation. Mud weight over the entire period was increased gradually.

Viscosities. Surface mud viscosities ranged from 55 seconds API at 142 F in the lower weight ranges to 190 seconds API at 115 F in the higher weight ranges. Estimated bottom-hole viscosities varied from 35-45 seconds in the lower weight ranges and from 70-80 seconds in the higher weight ranges.

Table 1 shows average surface mud properties at various well depths.

Temperature effects. Fig. 2 shows the viscosity versus temperature relationships for the minimum and maximum

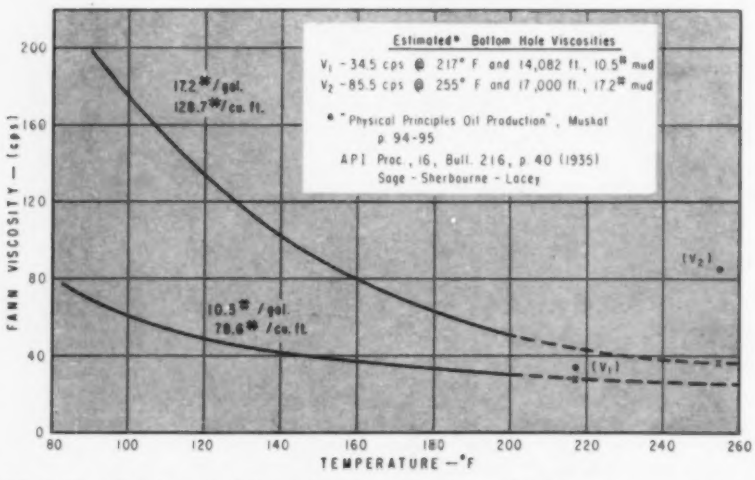


FIG. 2. **Viscosity characteristics** under atmospheric pressure for various temperatures of the new oil base drilling fluid used by Shell Oil Company in drilling the Caffery No. 6. Viscosity versus temperature is shown for the two extreme mud weights used in this well.

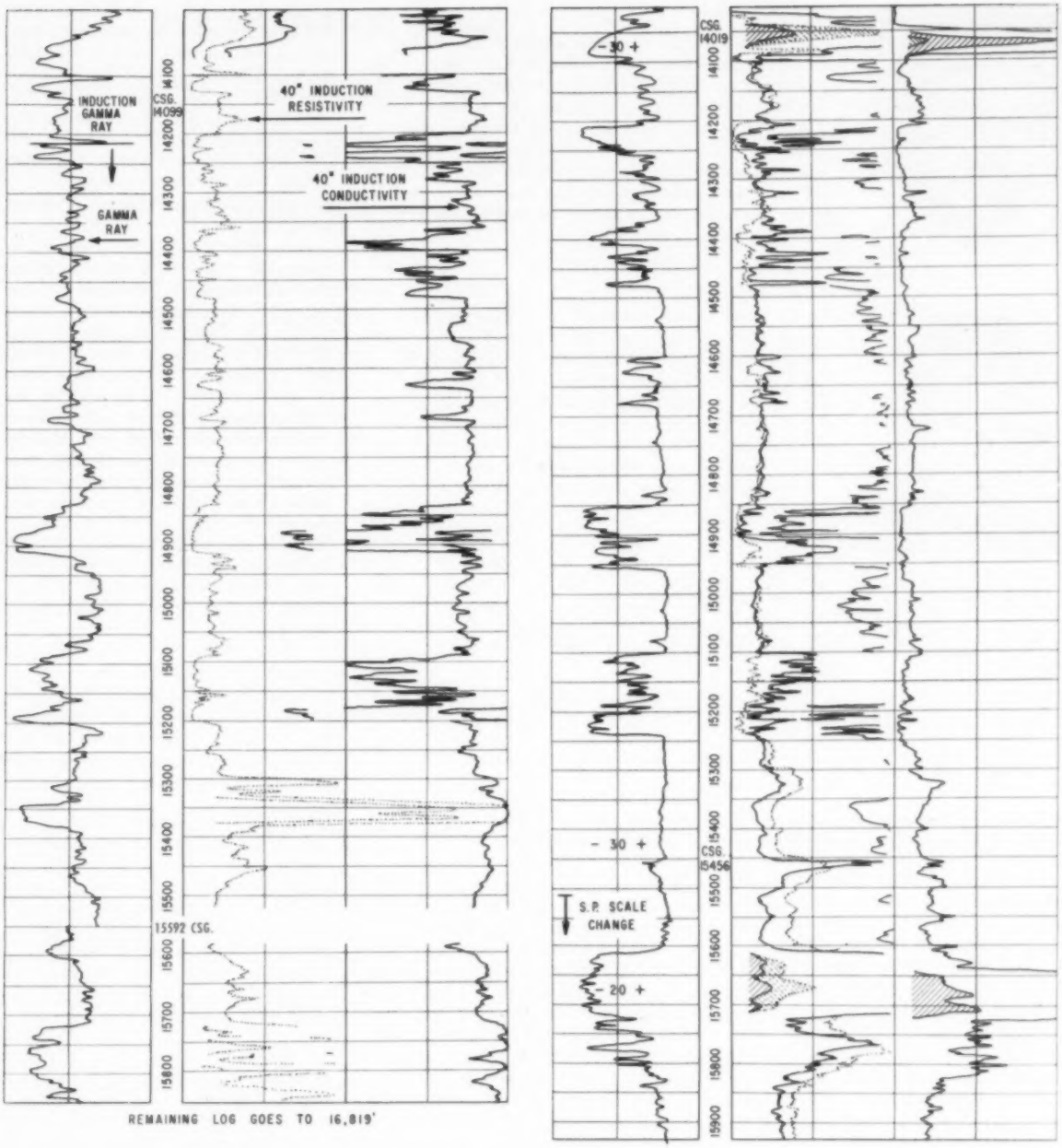


FIG. 3. **Good correlation** exists between conventional electric log (right) run in water base mud on Caffery No. 5, a 700-ft offset, and combination induction (conductivity and resistivity) and induction gamma-ray log run in new oil base mud on Caffery No. 6. Note definition of fluid content from induction resistivity and conductivity logs.

mud weights at atmospheric pressure. It can be seen from this curve that the surface viscosity of a true oil-base mud is affected by temperature. Therefore, the viscosity reading is apt to be misleading unless related to the temperature of the mud at the time of measurement. The down-hole viscosity of an oil-base mud is affected by both temperature and pressure, which tend to have offsetting affects.

Data published by Sage and others,[1,2] show that the viscosity of an oil increases 12-20 percent with each 1000 psi pressure increase. Using this approximation applied to the viscosity-temperature curve in Fig. 2, point V_1 is the estimated bottom-hole viscosity when the oil-base mud was first put in the hole and point V_2 is the estimated bottom-hole viscosity near total depth. It can be seen from the curve that these estimated bottom-hole viscosities are considerably less than those for the same mud weights at flow line conditions.

Fluid losses were zero, API, at all times during the operation.

Mud treatment. There were no chemical additions for maintenance purposes during the entire 99-day period. Seventy sacks (50 lb) of oil base gel were added for viscosity adjustment during the changeover. Thereafter, the only additions were barite for weight increases, diesel oil for viscosity

The Authors

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TABLE 2. Comparative mud costs.

Well No.*	Total Depth	Feet drilled below 9⅝in.	Mud cost (9⅝in.-TD)	Mud cost/ft (9⅝in.-TD)	Mud cost/day (9⅝in.-TD)
Average of Wells 1, 2, 3-A, 4, 5	16,887	2,718	$68,800	$25.30	$1,075.00
Well No. 5	15,919	1,826	54,000	29.60	915.00
Well No. 6	17,000	2,918	47,200	16.15	476.00

*Note: Wells 1 through 5 drilled with various types water-base oil-emulsion muds. Well No. 6 drilled with oil-base mud.

control and minor weight reductions, lost circulation material, and small volumes of pre-mixed oil base mud as necessary to maintain the desired circulating system volume. Because of the stability of the oil-base system, mud conditioning time was negligible.

There were no instances of stuck drill pipe or casing in the interval drilled with the oil-base mud.

Shale sloughing. An attempt was made to drill below the 9⅝-in. casing with 10.5 lb per gal mud. Soon after drilling out, sloughing began and grew progressively worse. Just as in previous wells, the mud weight had to be increased periodically to combat sloughing. Each increase of 0.4-0.6 lb per gal would decrease sloughing for a few days, then the mud weight required increasing again. By the time 15,607 ft was reached, the mud weighed 14.8 lb per gal and sloughing still persisted.

Running liner. Because of the lost circulation potential with higher mud weight and the sloughing condition, it was decided to set a 7-in. liner. Even though the bit and reamer had to be pumped out of the hole for 400 ft on the trip out to run the liner, the liner went to bottom. No centralizers were used and there were several massive normal pressure sands exposed. Success under these conditions indicated the oil base mud served to lubricate the liner to bottom.

Immediately after drilling out under the liner, mud weight was increased to 16.0 lb per gal and no further hole trouble was experienced to total depth.

TABLE 3.

Total mud materials, including 10.4 lb per gal water-base displacement mud		$68,000.00
1500-bbl storage tank		4,000.00
Extra rigging-shed over pits, drip pan, etc.		1,000.00
Halliburton displacement charges		500.00
Total Cost		$73,500.00
130 bbl of 16.5 lb per gal oil-base mud transferred to another well	$ 2,900.00	
1000 bbl of 16.0 lb per gal (avg weight) oil-base mud salvaged	21,400.00	
Storage tank salvage value	2,000.00	
	$26,300.00	$26,300.00
Net Total Cost		$47,200.00

A 5-in. liner was run to bottom without difficulty even though no centralizers were used and there was a 150-ft thick normal pressure sand just below the 7-in. liner. The pressure differential across the filter cake on this sand was approximately 6600 psi. Before reaching total depth the mud weight had been increased to 17.2 lb per gal because abnormal pressures were anticipated.

As a precaution against lost circulation, the mud system was pre-treated with approximately 5 lb per bbl of fine lost circulation material on drilling out of the 7-in. liner. Mud weight at that time was 16.0 lb per gal. A partial loss of circulation occurred at a depth of approximately 16,760 ft with the mud weight at 17.5 lb per gal. This was the highest mud weight ever used at Cote Blanche. The situation was brought under control through a weight reduction to 17.2 lb per gal and a supplementary treatment of fine lost circulation material. Approximately 70 bbl of mud were lost in the process and drilling was resumed in less than 12 hours. No further lost circulation occurred.

Analysis of Mud Costs

In analyzing the drilling fluid costs of that portion of the well below the 9⅝-in. casing to total depth, the following items were taken into account, as shown in Table 3.

Logging in Oil Base Mud

Reliance was placed on gamma-ray and induction surveys for evaluation of the formations penetrated, and a satisfactory evaluation was made. It was not possible to determine if the resistive sands were oil or gas bearing without drillstem testing. However, this same problem has been experienced in many wells in which oil-emulsion muds were used.

Correlation of the Caffery No. 6 gamma-ray log with the Caffery No. 5 electric log was satisfactory. Fig. 3 shows the pertinent sections of logs from both wells to illustrate the correlation between the logs of both wells.

Well Completion

Caffery No. 6 was completed in a Miocene sand below 15,000 ft. This completion was based entirely on information from logs obtained in the oil-base mud. On a drillstem test, the well flowed 460 bbl of oil per day on 10/64-in. choke.

References

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★ ★ ★

Slim Hole and Unique Completion Cut Well Costs Thirty-Six Percent

A mobile rig, small hole size, and permanent completion without a production string used in West Texas well

A. B. Vaught,
President, Vaught Drilling Company, Midland, Texas
and Lowell A. Murphy,
Field Editor

TOTAL WELL COSTS of drilling and completing a 7100-ft West Texas well were reduced some 36 percent by utilizing the benefits of slim-hole drilling and a unique permanent completion technique. A highly mobilized, modern rotary rig drilled the TXL No. 1-13, in Block 39 of Upton County to 7079 ft with 9⅝-in. hole to 365 ft and 6⅛-in. hole to total depth. Parallel strings of 2½-in. and 1-in. tubing were run and cemented. The Clearfork formation was then perforated and fractured and the well was tested at 240 bbl of oil per day.

Planning the Well

It has been well known that slim-hole drilling methods have offered considerable savings where the method is applicable. While it is not as popular in West Texas as in other areas such as the Denver-Julesburg Basin and East Texas, slim-hole drilling has proved to be a practical method in many parts of the Permian Basin. Since the method offered many advantages in this area and there appeared to be no special barriers to its application, it was decided to drill the slim hole.

A new well completion idea which is a modified form of the permanent completion technique, and one which requires no production string, was also applicable in this well. The completion of the well was supervised by Garrett Production Company of Longview, Texas, who has an interest in the well. The combination of savings offered by slim-hole drilling and the unusual well completion method resulted in large savings in overall well costs.

Drilling Rig

The slim-hole drilling rig which drilled the TXL No. 1-13 is owned and operated by the Vaught Drilling Company of Midland, Texas. Trailer-mounted for economical transportation, the rig has a depth rating of 7000 ft using 2⅞-in. drill pipe. Rating for well servicing and workover operations is 10,000 ft using 2⅞-in. drill tubing. The twin-engine power plant delivers 350 hp to torque converters. The 100-ft, guyless derrick, which is raised and lowered by a hydraulic system, has a capacity of 200,000 lb. The 7¼-in. by 12-in. slush pump is powered by a 220-hp engine with two-speed transmission for high pressure service.

Other equipment on the rig includes an 18-in. rotary table, 3½-in. by 38-ft kelly, 10,000-w light plant, steel mud pit, spider, slips, elevators and tongs for 2-in. or 2½-in. tubing, 4¾-in. drill collars, and power tongs for tubing and small liners to 4½-in.

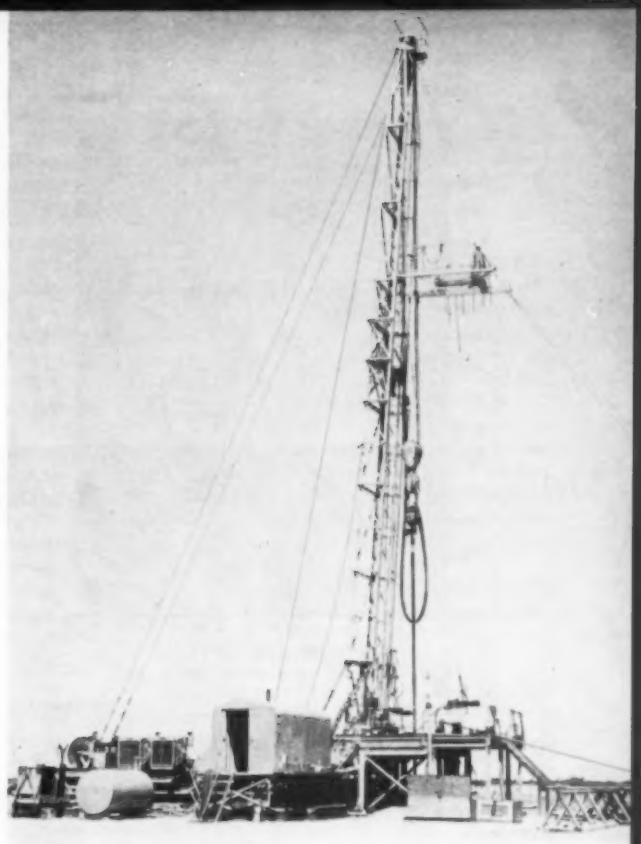

FIG. 1. Slim-hole drilling rig of Vaught Drilling Company, Midland, Texas, used 2½-in. drill tubing to drill the TXL No. 1-13 to a total depth of 7079 ft.

Drilling Program

This well was spudded in on September 6, 1957, and a 9⅝-in. hole was drilled to 350 ft. A string of 7-in. casing was set to the surface and cemented. After cement had set, drilling was resumed with a 6⅛-in. bit, encountering the usual formations of red bed, shale, and anhydrite to around 2000 ft. From 2000 to 3000 ft, considerable salt was encountered.

Just below 3000 ft, the drill tubing was twisted off above a tool joint and a fishing job resulted. It is felt that the twist-off was due to excessive rotary speed in a washed-out salt section.

After the fishing job, drilling resumed and encountered first limestone at around 3700 ft. The drilling rate decreased in the limestone, but increased again between 4100 and 4600 ft in shale, salt, and streaks of sand. Drill pipe stuck at around 4700 ft, but was freed with the addition of oil to the mud. Lime was hit at about 4800 ft and continued to 6000 ft, where streaks of shale were encountered. Shale and anhydrite continued to the Clearfork formation at about 7000 ft and the well was bottomed at 7079 ft after a total of 29 drilling days.

Thirty-three 6⅛-in. bits were used in drilling this well. The maximum deviation of the hole was measured at 1¾ deg. Drill collar weight was increased to 28,000 lb of 4¾-in. collars, but it is felt that a weight of 32,000 lb on the 6⅛-in. bits would be more satisfactory.

Mud hydraulics presented no problem in drilling this well. An estimated circulation rate of from 225-250 gal per min was maintained in the 2½-in. drill tubing with 4⅛-in. tool joints. The 7¼-in. by 12-in. pump was equipped with 6-in. liners which were reduced to 5½ in. at a depth of 5000 ft.

Mud cost was estimated to be at least 35 percent less than

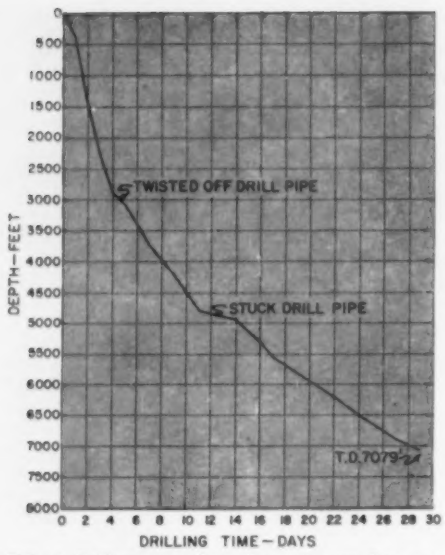

FIG. 2. Drilling rate chart shows the excellent rate achieved in drilling this Upton County well.

the average mud cost on conventional holes drilled in the area.

Drilling rate curve in Fig. 1 shows the progress of the drilling over the 29 days from spudding in to bottoming at 7079 ft.

Completion Program

Completion of this well varied from the conventional permanent completion in that a 1-in. macaroni string run parallel to the tubing and cemented in the open hole takes over the functions of the standard casing-tubing annulus. The small tubing string is connected to the production tubing string through six sliding sleeve gas-lift mandrels and one cement plug receiver mandrel. Communication from the surface to the lower part of the production tubing is provided through the macaroni string, permitting direct or reverse circulation of the well.

Running Tubing Strings

Fig. 3 shows the down-hole equipment as installed in the well. A perforated bull plug was made up on the end of a 10-ft tubing sub and the cement plug receiver mandrel was made up on the upper end of the sub. The macaroni string was then screwed directly into the mandrel plug. Tubing strings were run into the well until the first sliding sleeve gas-lift mandrel was made up in the production string approximately 175 ft above the cement plug receiver mandrel. Successive gas-lift mandrels were spaced approximately 800 ft apart, locating the upper mandrel of the six at 2885 ft.

The two tubing strings were run simultaneously in 12 hours with the macaroni string being connected to all gas-lift mandrels with a special slide coupling to join up between sleeves and to allow rotation for make-up. One-bolt clamps were attached to the tubing string at every third joint and centralizers were placed for even distribution of cement. The 2½-in. string was made up with power tongs at a platform in the derrick while the macaroni string was made up at the floor with hand wrenches.

Sliding sleeves in all the gas-lift mandrels were closed as they were run into the well and the sleeves were packed with silicone grease to prevent cement from adhering to the sliding surfaces.

Cementing the Well

The cementing procedure in this type of completion entails pumping the cement down the large tubing, out the perforated bull plug, and up the hole around the two strings of tubing. The cement slug is followed with a drillable cement plug which lands and locks in the cement plug receiver mandrel, effectively preventing back-flow. However, while pumping cement in the TXL No. 1-13, the cement set up with 135 sacks in the tubing and 165 sacks outside the tubing. The cement plug, which was being pumped in with oil when the cement set, was atop the column of cement in the tubing at approximately 400 ft.

Cement was drilled out of the tubing from 400 ft to total depth in 60 hours using 1⅝-in. drill pipe and one fish-tail drag bit. Sliding sleeves in the gas-lift mandrels were then operated and all were found to be free of cement, having

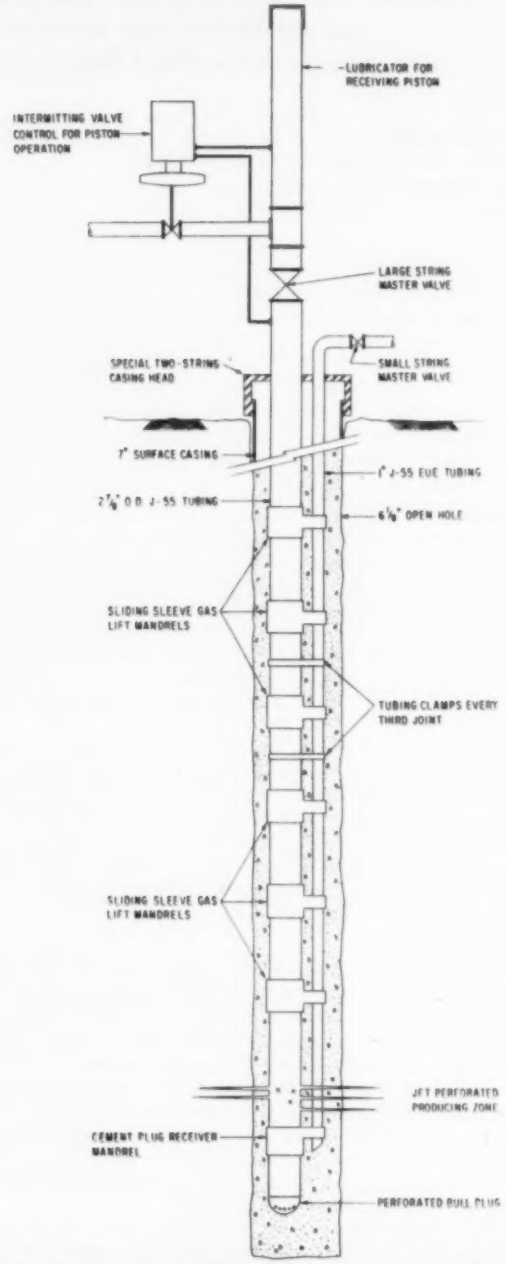
LUBRICATOR FOR RECEIVING PISTON
INTERMITTING VALVE CONTROL FOR PISTON OPERATION
LARGE STRING MASTER VALVE
SPECIAL TWO-STRING CASING HEAD
SMALL STRING MASTER VALVE
7" SURFACE CASING
1" J-55 EUE TUBING
2⅞" O.D. J-55 TUBING
6⅛" OPEN HOLE
SLIDING SLEEVE GAS LIFT MANDRELS
TUBING CLAMPS EVERY THIRD JOINT
SLIDING SLEEVE GAS LIFT MANDRELS
JET PERFORATED PRODUCING ZONE
CEMENT PLUG RECEIVER MANDREL
PERFORATED BULL PLUG

FIG. 3. Permanent completion of TXL No. 1-13 uses macaroni string to replace usual casing-tubing annulus. Tubing strings are cemented in open hole. Wellhead control arrangement illustrated here is for free-piston production.

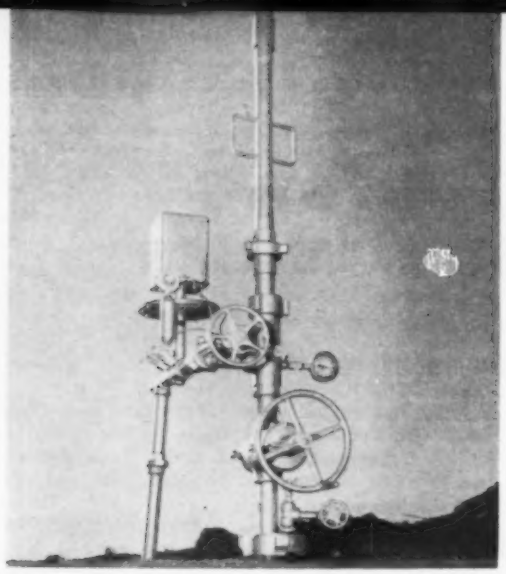

FIG. 4. Compact wellhead controls free-piston production of well. Lubricator catches the piston at upper end of its travel which is controlled by intermitting valve control on the flow line.

been protected by the silicone grease packing. The cement job was tested to 3000 psi.

Perforations

With oil in the hole, the interval from 6998 to 7010 ft was perforated with jet tubing gun. Perforation density was four holes per foot.

Fracture Treatment

After the Clearfork formation was perforated, 500 gal of mud acid were squeezed into the formation. This was followed by a formation fracture treatment consisting of 2000 gal of mud acid, 40,000 gal of heavy refined oil, and 30,000 lb of Ottawa sand, all pumped together. Pump-in rate was approximately 9 bbl per min with a surface pressure of 4000 psi. During the fracture treatment, pressure on the macaroni string at the surface was around 1200 psi. Since the macaroni string was in communication with the bottom of the tubing string, this indicated a friction loss in the tubing of around 2800 psi during the treatment. The fracture treatment was followed with an overflush of 140 bbl of lease oil.

Production

After the primary acid job, the well was swabbed for eight hours to recover spent acid and mud. After the fracture treatment, the well was swabbed for 12 hours and put on production. Free-flow production continued for 12 days to allow the well to clean up completely before a free piston was placed in the well. Production was then tested at 240 bbl of oil per day against a 20/64-in. choke.

This type of completion permits production by any type of artificial lift method, including gas-lift, free piston production, beam pumping, and hydraulic pumping, as well as by natural flow. The TXL No. 1-13 is producing with a free piston which incorporates pack-off sealing elements against the pipe walls to bring a slug of fluid to the surface. When the piston arrives at the surface, it enters a lubricator and effects to closure of a valve in the flow line. The piston is then released and falls freely to the bottom of the well in from seven to ten minutes. The control at the surface then opens the flow line and the piston begins another trip to the surface with its load of fluid, usually taking around 37 minutes to make the trip.

One of the major advantages of free-piston production is the elimination of troubles caused by paraffin. Each time the piston makes a trip, paraffin is automatically removed from the tubing. Other wells in the area producing by natural flow require weekly paraffin clean-outs.

Another benefit realized from free-piston production is the production of water which would not be produced in a natural flow well and which would load up and kill the natural flow well.

Savings

In addition to the savings realized from the slim-hole drilling techniques and aside from the reduction in workover costs during the life of the well, considerable savings are effected in the original completion. One of the major items of savings is the elimination of production casing since only a surface string is set with the tubing string extending on into the open hole.

Another major savings realized in this completion is the simple wellhead hook-up, requiring one master valve for the production tubing and one master valve for the macaroni string. Other wellhead equipment includes a lubricator for receiving the free piston and the intermitting valve control for operation of the flow-line valve and control of the piston travel.

Table 1 is an analysis of the costs incurred in drilling and completing the TXL No. 1-13, from preparing the location to bringing the well to production. It is estimated that the cost of conventional completions in this area is approximately $82,500. Therefore, the techniques and methods used in the drilling and completion of this well represent a saving of nearly $30,000 over conventional completion.

Table 1. Well Cost Analysis — TXL No. 1-13, Upton County, Texas.

1. Stake and clear location	$ 260.00
2. Contract drilling to 7070 ft	21,697.50
3. Surface casing—363 ft, 7-in. O. D., used	650.59
4. Mud, chemicals and oil for drilling	3,986.73
5. Cement—surface casing and tubing strings	1,549.64
6. Gamma ray and neutron log	1,017.49
7. Perforations—48 holes	840.42
8. Tubing—7150 ft, 2⅞-in. O.D., J-55	6,327.75
9. Tubing—6925 ft, 1-in., J-55, EUE	2,664.05
10. 6 gas-lift mandrels with clamps, macaroni couplings, centralizers, cement plug and landing nipple	3,213.28
11. Royalty charge—10 cents per ft	707.00
12. Tubing head and wellhead equipment—master valves, gages, choke, etc.	844.53
13. Free piston, lubricator, tubing stop and time cycle controller	1,183.57
14. Acidizing	573.36
15. Sand, oil, and acid fracture treatment	6,851.63
16. Wireline truck service	110.00
17. Swab truck—22 hr	308.00
18. 10 Swab cups	50.00
Total	$52,835.54

Future of Practice

There have been very few periods in the history of the oil industry when the need to cut well costs is as important as it is today. The cost of equipment, materials, labor supervision, taxes and overhead have continued to climb. And, if the industry is to maintain its relatively high rate of well completions every year in the face of increasing costs, it will be necessary to hold the line wherever possible. Admittedly, the practices described above will not apply in every oil producing area, but by careful study and analysis, some of these ideas can be employed when applicable to the end that well costs can be reduced and the industry can continue to drill the necessary number of wells to prove up additional reserves. Slim-hole drilling and unique completion ideas such as employed in the TXL No. 1-13 offer tremendous possibilities in this direction.

Acknowledgment

The authors gratefully acknowledge the assistance provided by A. L. Moffett and John W. Davis of Garrett Production Company, Longview, Texas, for data and information concerning the drilling and completion of the TXL No. 1-13.

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Part 1 of 2 parts

Sand Exclusion in Oil and Gas Wells

Comprehensive treatment of bridging and consolidation techniques and modern applications of each, including equipment and methods

G. H. Tausch and C. B. Corley, Jr.

Humble Oil & Refining Company, Houston, Texas

METHODS of sand exclusion were first used in water wells and were later applied in oil and gas wells. Unsuccessful attempts to prevent sand production in oil wells usually may be attributed to a failure to recognize the effects of: 1. Type of well completion; 2. formation characteristics; 3. type of completion fluids, and 4. completion technique.

Two general methods of sand control have been universally used in oil and gas wells, viz., bridging and consolidation of sand grains in place. Bridging sand grains may be accomplished by the use of screens, gravel packs, or plastic-coated walnut shells. Sand-grain diameter or sieve analysis, completion fluids, and completion techniques are of prime importance when utilizing bridging techniques. The consolidation of sand, however, is accomplished by the use of plastics, with formation permeability and temperature being of major importance. The anticipated producing rate, length of time between workovers, location and depth of wells — all affect the economics of sand exclusion and are factors in selecting a method of well completion. The use of a rig or wire line with through-the-tubing tools may also control the selection of a completion method.

A matter of producing rates. Sand control has long been a problem associated with the production of water from wells where, in the past century, screens were successfully used as a means of preventing sand production. Sand was not controlled but was produced in the early history of the oil industry. A classic example might be the use of the agitator string.[1] This was an additional string of casing or tubing used in the early California oil fields that enabled agitation of the sand-bearing fluids and prevented sand from settling in the wells. As the flowing life of wells terminated, the problem of pumping often became insurmountable. Wells flowed sand but could not be pumped at slow rates. There were several misconceptions during this same era, e.g., oil could not be produced without sand and sand production could not be completely stopped without shutting off oil production.

The production of sand from oil or gas wells is a matter of rate sensitivity — i.e., there is a producing rate below which very little, if any, sand will be produced and above which sand production will occur. Often the low producing rate that will not cause sand production is uneconomical. Therefore, sand production must be controlled. It is this rate sensitivity that comes forcibly into play, causing initial sand production when water production commences in an oil or gas well. As the percentage of salt water increases, the fluid-withdrawal rates from the well are increased to obtain the allowable or profitable oil production.

It is possible that water in which a sand was deposited is not the same as that in the present aquifer and, therefore, the produced water may dissolve a portion of the cementitious material and cause a sand to become unconsolidated. Although this is possible, it has been difficult to duplicate in the laboratory or observe in field operations, and it is considered that the fluid withdrawal rate is the prime cause of sand production. There is evidence that when formation pressure is reduced, sand compaction can take place to cause a shearing of the cementing material between sand grains.

Two primary methods. Sand control methods may be divided into two main categories: 1. Sand bridging, and 2, sand consolidation. Bridging sand grains may be engendered by: 1. Screens or slotted pipe; 2. gravel packing, or 3. plastic-coated walnut shells.

Sand control by any bridging technique initially involves a correct evaluation of sand size to determine the proper-size screen slot or the proper particle size for packing. Sampling of an unconsolidated sand for sieve analysis is difficult. Sand produced at the surface may often be the finer particles, while the sand bailed from the well bore is usually only the coarser particles. A core of the formation sand is the only proper way to obtain a sample.

This has been extremely difficult to accomplish in the past, but may be facilitated by a new core barrel designed for this purpose.[2]

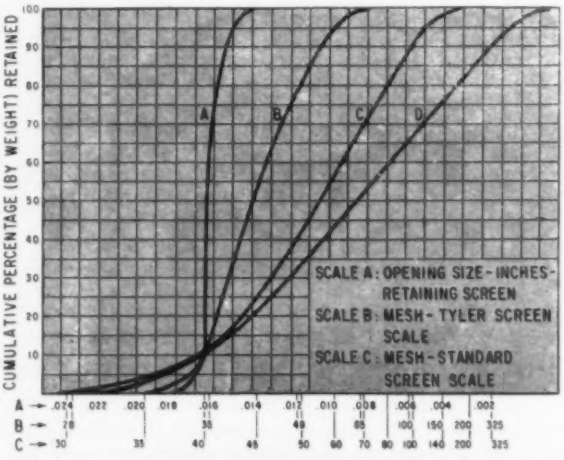
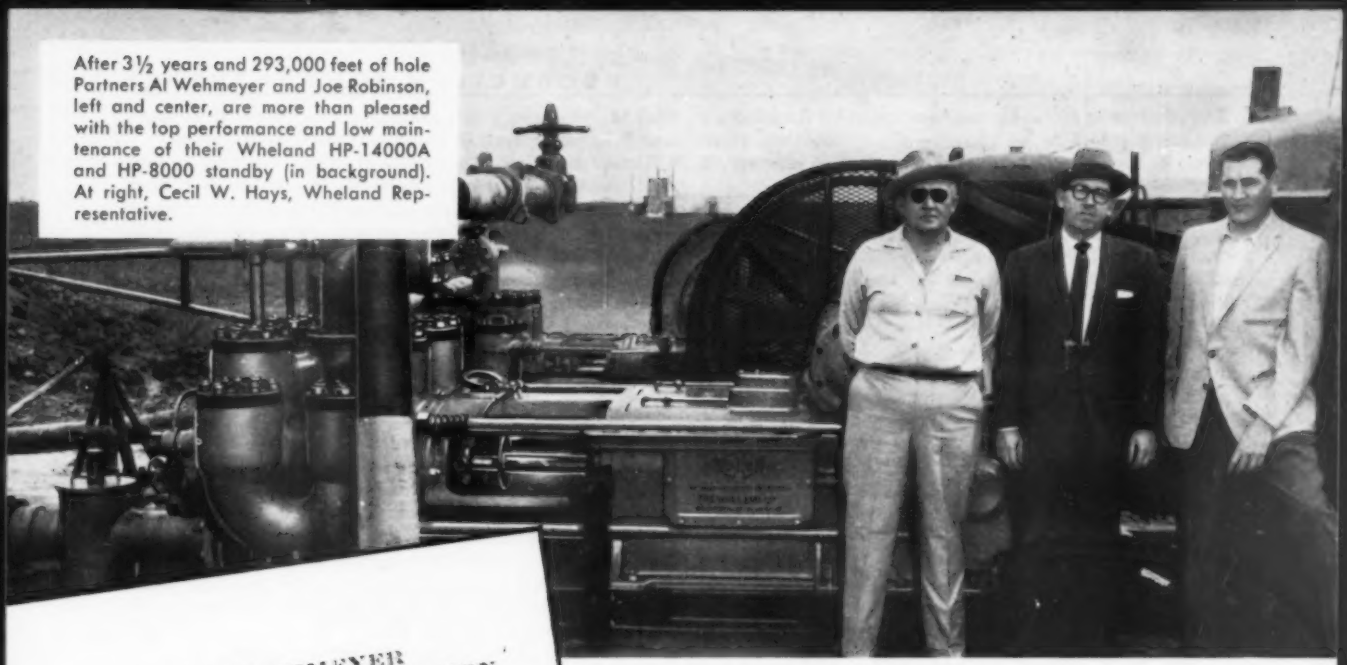


FIG. 1. Sieve analysis of four different sands. Although each sand may have different quantities of fine and coarse grains, the 10 percentile point is nearly the same.

Based on a paper by the same title presented at the Spring Meeting of the Southern District, API Division of Production, Houston, Texas, February 26-28, 1958, and published here by special permission of the American Petroleum Institute.



After 3½ years and 293,000 feet of hole Partners Al Wehmeyer and Joe Robinson, left and center, are more than pleased with the top performance and low maintenance of their Wheland HP-14000A and HP-8000 standby (in background). At right, Cecil W. Hays, Wheland Representative.

ROBINSON-WEHMEYER
DRILLING & EXPLORATION

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Very truly yours,

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The controlling factor for sand exclusion by the bridging technique is generally the 10-percentile point of the sieve analysis or the size of the sand particle at the coarsest 10 percent by weight. The 40 or 50-percentile point has been used in some areas as a control criteria but has not been generally accepted. The 10-percentile point of a number of formation sands may be identical in size and yet each sand may have a different quantity of fine sand grains. (Fig. 1). Although the 10-percentile point is the controlling factor and fine sand grains are ignored, it may be prudent to reduce the slot width or particle size when controlling sand containing a large proportion of fine grains.

When using screens or slotted pipe, the slots are of such a width that they will generally pass a large proportion of the sand but will bridge at least the coarsest 10 percent of the sand. These coarse sand grains will, in turn, bridge the next smaller size sand grains and the process is repeated until a stable bridge is formed. Gravel packing is the substitution of coarser particles around the well bore to permit the use of larger screen slots and secure higher well productivities. Gravel packing has been used for many years in the waterwell industry, and it is interesting to note that the formation sand size usually encountered in shallow water wells may be as large as the gravel size used for gravel packing in deeper hydrocarbon-bearing formations.

Approximately 15 years ago, research into sand control produced a technique of consolidating sand grains in place with plastic. This consolidating plastic must not be confused with plugging or filler plastic used as a substitute for cement. The sand-grain size is not too significant when consolidating plastic is used. However, low-permeability sand containing excessive amounts of argillaceous material may limit the successful use of the plastic currently available.

A sand-control technique, previously attempted but found unsatisfactory, was the continued production of sand to create a sufficiently large cavity to stop sand production by reducing the fluid withdrawal rate per unit area of exposed sand face. Excessive sand production removes support of the upper formations and is the cause of many collapsed or shifted casing and liners resulting from the caving of shale beds or other formations above the producing interval.

WELL COMPLETIONS

The rate of production that causes sand production must be considered as a rate per unit area of permeable formation open for production. The tendency to sand production may be reduced by increasing the formation area open to production by fracturing, by maintaining open perforations, or by increasing the length of perforated interval or open hole. An increase in length of perforated interval should not be confused with an increase in shot density, inasmuch as present-day perforating guns provide satisfactory well productivities without excessive shot density if the perforations remain unplugged. Likewise, although increasing the length of open hole may reduce the tendency to sand production, under-reaming of open hole will have little effect unless the under-reaming removes a surface skin damage.

Prior to applying sand control in unknown areas, it should be definitely established that sand production will occur when the formation sand face is undamaged and exposed. Perforating should be performed in a clean fluid. Sand production has been reduced or stopped completely in some fields when the tubing-type perforator was correctly used. It is generally more economical to utilize sand-exclusion techniques on initial completion than after severe sanding problems. However, it should be established that a sand problem exists because the unnecessary use of these techniques may far off-set this cost advantage. At the present time, enough is known of regional sand trends in the Gulf Coast that generalizations can be made to the effect that Miocene sands in Louisiana above 10,000 ft in depth and Frio sand trends in Texas may need sand control.

Completion fluid. The choice of completion fluid as well as completion technique affects the formation area open for production. Special completion fluids such as oil-water emulsions are now proving popular. However, the most economical fluid is generally formation salt water when it is readily available and may be safely utilized. Salt water native to the formation is preferable. When a salt water foreign to the formation is used, it has been found that the addition of calcium chloride will prevent clay swelling and aid in preventing formation damage. Calcium chloride is added in the ratio of 1 lb to 4 lb of sodium chloride.

Flow rate. Although the completion technique and fluid are important, the rate at which flow is induced may also initiate sand production. When perforating with a pressure differential into the well bore, this differential should be small or the tubing should be full of fluid. Converted to a daily producing rate, fluid withdrawal rates achieved while swabbing may be extremely high, and as such constitute a potential hazard in sand-producing areas. Unloading wells at high rates also should be avoided when utilizing gas litt or other means of artificial lift.

SCREENS AND SLOTTED LINERS

The use of screens or slotted liners demands a correct evaluation of the slot width necessary to exclude sand production. Work by Coberly[3] with spherical steel balls determined that a slot twice the size of the diameter of the balls would cause bridging of the spheres on the slot. This determination has become the accepted formula for determining slot size using the grain diameter of the sand at the 10-percentile point. For example, if the 10-percentile point were 0.01 in., the screen size customarily selected would be 0.020 gage or 0.020 in. in slot width.

Slotted liners have consisted of many forms varying from torch-cut slots, large in size and totally incapable of stopping the fine-grain sands normally encountered in the coastal areas, to horizontally (Fig. 2A) or vertically (Fig. 2B) saw-cut slots. The slot size of wire-wrapped screens (Fig. 2C) is determined by the proximity of each wire to the adjoining wire as they are wrapped around the circumference of a large slotted or perforated pipe.

Many other types of screens have been used over the years; e.g., porous carborundum, sintered metal, porous ceramic, porous plastic, and prepacked gravel-pack screens (Fig. 2D). The porous materials have generally been constructed as cylinders that slip over a coarsely perforated pipe or fit between two perforated pipes for protection or have been constructed as button inserts in blank pipe. Prepacked screens have consisted of aggregate such as gravel, coarse sand, glass beads, and other hard spherical graded material that is tamped and packed between two slotted screens. In some cases, this aggregate has been consolidated with plastic to form a porous cylinder having a high permeability and protected by the surrounding slotted pipe. These porous screens offer high permeability with the ability to exclude very fine particles of sand. However, they will also generally plug with the clay particles or filter cake in drilling mud before oil or gas flow can be established. Porous materials, particularly those similar to plastic or ceramics, are very susceptible to breaking and their use has virtually been eliminated within the oil industry.

Screen selection. The selection of the proper type screen, once slot size has been determined, is largely a matter of well conditions. Saw-cut slots are more economical and permit easier fishing operations, with some benefit being derived by horizontally placed slots because this eliminates the necking down of the liner during retrieving operations. A wire-wrapped screen usually permits the use of much harder metal that will more satisfactorily withstand the abrasive action of fine sands and fluid before a stable

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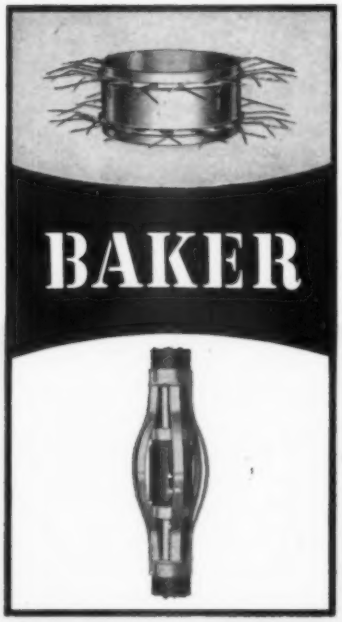

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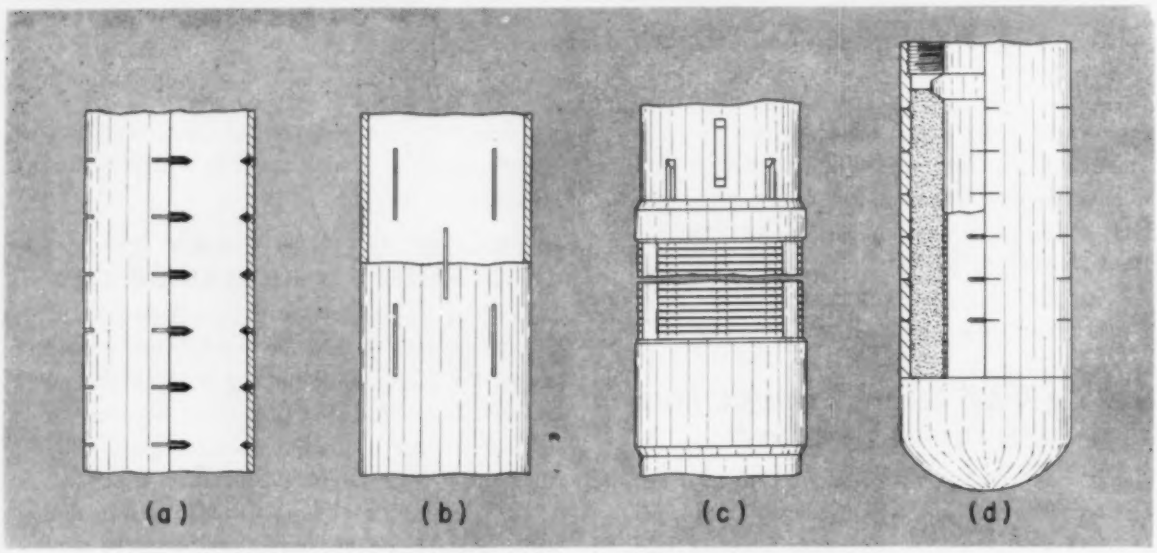

FIG. 2. Types of screens for sand control: (A) Horizontal slotted screen; (B) vertical slotted screen; (C) wire-wrapped screen, and (D) prepacked screen.

bridge is formed. It is also generally the more economical method of constructing a screen that must be composed of corrosion-resistant material inasmuch as only the wires and supporting ribs need be made of this material. This type of screen does have the disadvantage of greater thickness which may restrict the use of tubing or tools within the screen. In many cases it presents a more difficult fishing problem because the wire frequently strips off the screen if it is necessary to cut the inner pipe.

Importance of completion fluids. The effect of the completion fluid and technique cannot be over-emphasized when using screens or slotted liners. These screens are constructed to cause a sand bridge and will, therefore, bridge any sand contained in the drilling mud or in the mud filter cake present on the formation sand face. This in turn will form a mud filter cake over the bridged sand at each slot.

When running a screen without a wash pipe, it is not uncommon to circulate mud through the screen, have it plug, retrieve it from the well, and find small filter cakes composed of clay and sand covering each slot on the screen. To overcome this difficulty, some operators have initiated the use of various completion fluids that do not contain clay particles. When using this type of completion fluid, it is imperative that mud filter cake from previous drilling mud not be present on the formation sand face. Oil-base drilling mud has been popular as a completion medium of this type. However, it is capable of being retained on a sand face and therefore will be retained on sand bridged around the screen. Various gels or emulsions that are used for this purpose must have the capacity of breaking and flowing through the sand upon the application of pressure or be destroyed by a second fluid pumped through the screen.

Other techniques are: 1. Allow the well to flow on the casing annulus until all possible mud and mud filter cake have been removed and then set the liner packer and bring the well in through the screen, or 2. displace all drilling mud with clear water and wash the well to remove mud filter cake before setting the liner packer and completing the well. The first of these latter techniques is more hazardous but more successful in preventing the formation of mud filter cake over the screen slots.

A number of screens were formerly used that contained an inner-cement sheath which prevented flow through the screen until the sheath was removed after cleaning the formation walls and setting the liner packer.[4] The apparatus most commonly used today consists of an extension of tubing called a wash pipe which extends into the back-pressure valve of the screen and permits circulation through this valve, preventing any circulation through the slots. A liner hanger and packer has been designed which permits liner rotation while cementing. This type hanger may also make possible the use of wall scratchers with screens so that mud filter cake can be removed while circulating water around the screen.

Screen size. Even when the formation face is free of mud filter cake, large amounts of caved shale can create a partial or complete blocking of the screen as the formation is packed around the screen and the shale particles cover the slots. For this reason, it is more desirable that the screen be sized to fit as closely to the formation face as possible. This is particularly true in open-hole completions. Some operators have under-reamed the hole in an effort to remove mud filter cake and have immediately created a problem of shale blocking of the screen. The fit of screen to formation face may also control the creation of channels resulting from shifting sand and shale that cause high-ratio production and bring reservoirs into communication. It is not unusual to have ratio problems and cement failures around the casing seat when excessive sand production occurs from open-hole completions. This same problem has been exhibited to some limited degree when a screen was set in an enlarged hole.

Location of screens. Screens are normally set in open hole extending below the casing, in the casing opposite perforations, suspended on the lower end of the well tubing, or as a permanent part of the lower end of the casing. The practice of using a screen or perforated pipe for the exclusion of sand as a permanent part of the lower end of the casing (combination string) is inadvisable in sand-producing areas because it cannot be removed upon failure. The screen on the lower end of the tubing will act as a conventional inside screen if placed opposite the perforations but will merely aid in forming a sand plug in the casing if the screen is suspended above the perforations. The screen set inside the casing opposite perforations is subjected to a jetting action from the one or more open-perforation holes until a stable sand bridge is formed between the screen and casing. Therefore, it is imperative that the well be brought in slowly with a low velocity of fluid movement

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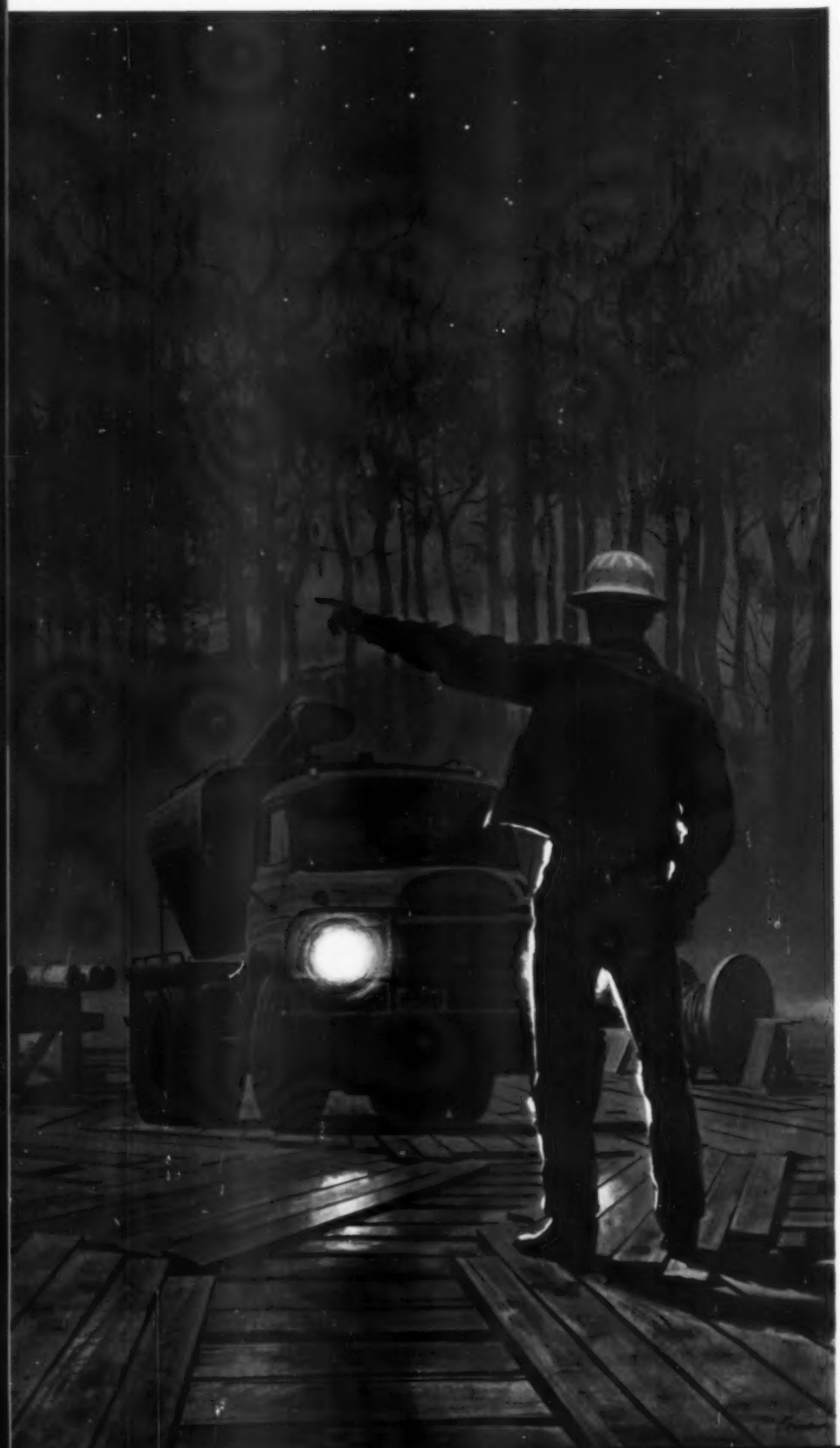

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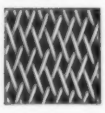

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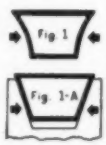

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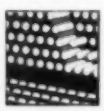

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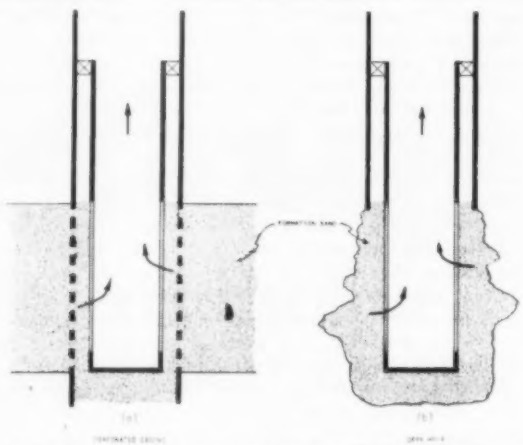


FIG. 3. Conventional screen and liner installations: (A) Screen set inside casing opposite perforations, and (B) screen set in open hole section.

through the perforation holes and screen to establish a stable sand bridge. The inside screen will also reduce the productivity of perforated wells (Fig. 3A) inasmuch as the open-perforation holes and a portion of the well bore will have a low-permeability sand in this interval. The screen used in open-hole completions (Fig. 3B) will have very little effect upon well productivity. A productivity change is generally not noticed unless a large cavity exists and sand is bridged on the screen, thereby reducing the area for fluid entry into the well bore.

Cleaning a screen. When screens are plugged during initial completion or during the life of a well, cleaning techniques have often been used. Among these are the string shot composed of primer cord, which cleans the slot by a force from the inside of the screen, the pressure washer composed of swab cups and utilizing pump pressure to wash fluid through the slots, and the suction or hydrostatic washer which also uses swab cups to isolate the slots and utilizes the hydrostatic fluid head within the casing annulus or tubing to flush fluid through the slots. As the mud filter cake, sand, or shale is removed from the outside of the slots by forcing it toward the formation face, these materials will again cover the slots of the screen unless by some manner they are removed from the well.

Although shale and sand cannot be removed, they can be rearranged and mud particles can be removed by constant washing action if they are alternately forced from the screen and brought back in contact with the slots. For this reason, a hydrostatic washer, which permits repeated washing and does not maintain a pressure that holds the particles against the sand face, will sometimes show results in increased well productivity.

Running screens. Not only may screens be run on tubing with a rig, but small slotted screens with blank liners may be run on a wire line and suspended from a landing nipple in the well tubing. These screens are set opposite the producing zone with the blank liner extending to the mandrel in the landing nipple. Steel 1¼-in. or 1½-in. nominal-sized heavy pipe is used for both screen and liner with flush-joint connections in the screen section and a bull plug below the screen. A shear-pin safety joint may be installed in the blank liner to permit retrieving the mandrel-locking device should the screen become sanded. The screen may then be pulled with a swab line and hydraulic jars.

GRAVEL PACKING

One of the first considerations in designing a successful gravel-pack installation is to determine the correct gravel-to-sand-size ratio. This ratio was originally established by using the diameter of the circle inscribed by the gravel grains in hexagonal packing as a measurement of the slot size that would successfully cause sand bridging. On this basis, a ratio of 13 to 1 was originally suggested.[5] Later investigators[6] reduced this gravel-to-sand-size ratio to 8 or 10 because of the inaccuracies in formation sand or gravel measurement, as well as problems in proper packing. Because the permeability of the sand-gravel interface is approximately the same in the gravel-to-sand ratios of 4 to 6 as it is in the range of 6 to 10, the former ratio is now being used and permits a much greater safety factor (Fig. 4). For example, if the sand grain diameter is 0.01 in. at the 10-percentile point, the gravel used would be 0.04-in. to 0.06-in. diameter. Three gravel sizes are commonly used in the coastal areas where sand problems are severe: 1. 0.04 in. to 0.06 in. (16 to 10-mesh sieve); 2. 0.03 in. to 0.04 in. (20 to 16-mesh sieve), and 3. 0.02 in. to 0.03 in. (30 to 20-mesh sieve).

The slot size of a screen need only be small enough to prevent passage of all gravel. For example, a 0.030-gage to 0.040-gage slotted screen could be used with 0.04-in. to 0.06-in. gravel. However, somewhat smaller slots are used to prevent individual gravel grains from wedging in the slots and reducing the effective slot openings. In practice, a 0.020-gage screen is used with 0.04-in. to 0.06-in. gravel, 0.018-gage with 0.03-in. to 0.04-in. gravel, and 0.016-gage with 0.02-in. to 0.03-in. gravel. Because a failure of the screen would mean a failure of the gravel pack and because enlargement of the screen slots by corrosion would result in the passage of gravel, it has become customary in some areas to reduce the screen-slot size to values in order of 0.010 gage to allow for enlargement of the slots.

Thickness of gravel pack. Investigators have indicated that the thickness of the gravel pack need not be very great to successfully bridge sand, and a thickness equal to four or five times the gravel-grain diameter has been considered satisfactory.[7] It is imperative, however, that the gravel around the screen be packed tightly and fill all cavities so that an eventual shifting of the gravel may be prevented. To compensate for gradual shifting or rearrangement of the pack that will take place under normal producing conditions, a reserve supply of gravel is provided around the blank liner within the casing above the open hole or perforations. In areas where shifting of the formation sand and rearrangement of the pack allows this reserve gravel to be utilized over a period of time, it is sometimes the practice to add additional gravel periodically so that a reserve is constantly maintained.

Gravel placement. The placement technique with gravel packing is one of the major sources of trouble. The existence of a mud filter cake on the formation sand face behind the gravel sandwiches an impermeable barrier between two permeable beds. Although it may not completely stop oil production, it will usually reduce well productivity.

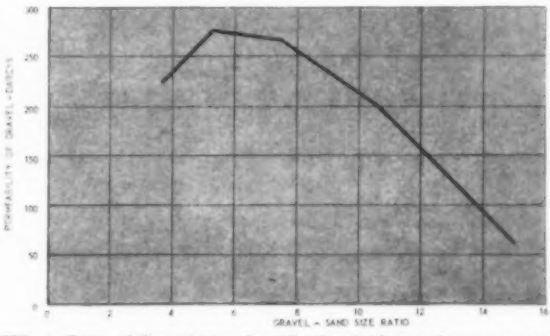


FIG. 4. Permeability of gravel pack after bridging shows greatest permeability in the 4 to 6 sand size ratio, now being used.
(After K. E. Hill, API, Drilling and Production Practices, 1941.)

When gravel packing inside perforated casing, the use of drilling mud or a nonpenetrating fluid restricts the ability to force gravel into all cavities behind the pipe and makes it virtually impossible to obtain a tight gravel pack outside the screen. To deposit gravel behind perforated pipe requires that the carrying fluid penetrate the formation sand. This is impossible if the carrying fluid contains sufficient clays to eventually build a filter cake. Although the gravel-packing fluid may be of a penetrating type, such as formation water, the existence of plugged perforation holes inside the casing will prevent fluid drainage to the well once gravel covers these mud plugs. Fluid will be obtained only from the previously opened perforations, thereby not obtaining the well's full potential productivity. For this reason, perforation washing is considered very desirable if the well was previously perforated in mud or if mud has ever been used to kill the well.

Casing Perforations. When discussing perforated casing and gravel packing, the size of the perforation holes must also be considered. In old wells that were originally perforated with jet guns, it has been considered beneficial to reperforate the wells with bullets or modern jets with a density of approximately one shot per foot to obtain large perforation holes that will satisfactorily permit the passage of gravel outside the casing. Although satisfactory sand control can be obtained by bridging gravel inside the perforations and packing it tightly between the casing and screen, this does not always prevent the movement of shale or sand that may either block perforations or create a cavity to water or gas with resultant ratio problems.

When washing the perforations of old wells, it has often been found that only one to two feet of the perforated interval have actually been penetrated by the obsolete bullet or jet guns then used, and reperforating of the entire interval is necessary. The presence of intact shale beds behind the perforations often prevents circulation while washing perforations, and these should not be confused with inadequate penetration. Generally, circulation can be established above and below the shale stringers.

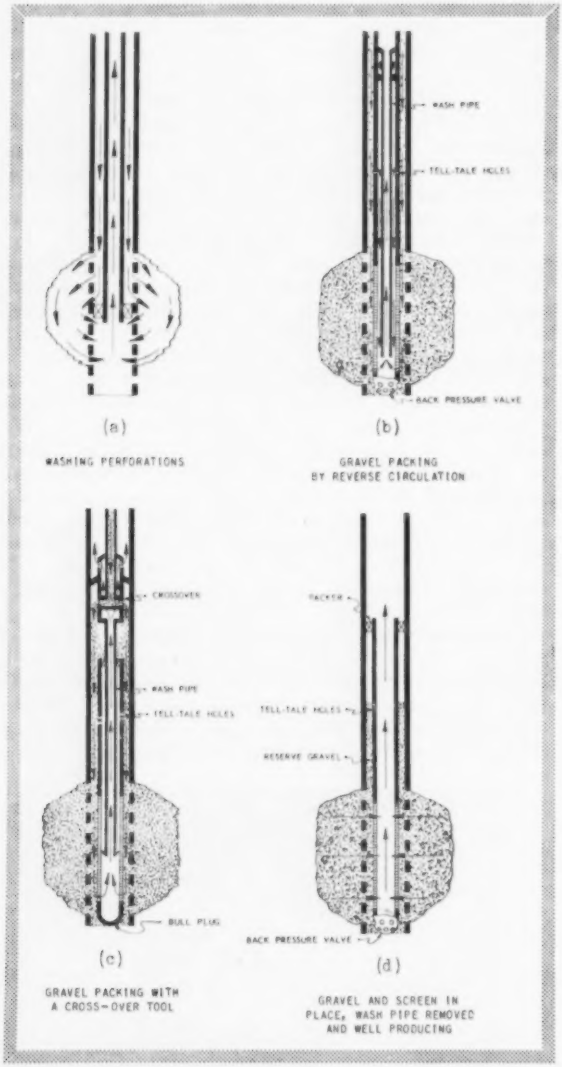


FIG. 5. Reverse circulation and cross-over method of gravel packing are illustrated in these four diagrams. The reverse circulation method is indicated by (A), (B), and (D) . . . one of the earlier and still popular methods. Gravel packing with a cross-over tool is demonstrated by (A), (C), and (D).

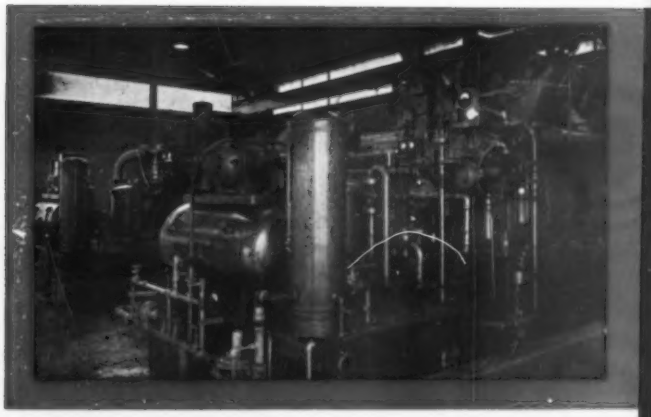
Reverse circulation method. One of the earlier gravel-packing techniques used and still used to some limited extent is the method of reverse circulation (Fig. 5A, B, and D) by which the gravel is forced down the casing-tubing annulus with a carrying fluid and is deposited around the screen on the lower end of the tubing as the carrying fluid passes through slots in the screen and returns to the surface through the tubing. This process has the disadvantage of being time consuming, occasionally sticking the tubing, and scouring the casing wall carrying all scale and debris into the pack around the screens. Should sand slough or cave during this process, it will be deposited around the screen without the knowledge of the operator.

The cross-over method. One common method of gravel packing still used is the cross-over method (Fig. 5A, C, and D) by which the gravel is pumped down the tubing or drill pipe, crosses over immediately above the screen, and is deposited around the screen as the carrying fluid passes through the screen slots and up the wash pipe to a point above the cross-over device where it returns to the surface through the casing annulus. The cross-over device contains a swab cup which isolates the casing annulus from the screen.

To control the height of the gravel around the screen by this process and the reverse circulation process, a series of slots or small holes called tell-tale slots is provided near the top of the blank liner so that a circulating pressure increase is exhibited as the screen is covered with gravel. An upward facing swab cup may be utilized on the lower end of the wash pipe to direct the path of the circulating fluid through the screen slots, assuring a tight pack of gravel around the screen. The swab cup also may be reciprocated across gravel bridges around the screen to break the bridge and obtain a continuous pack.

A variation of this technique, which does not permit the use of a swab cup on the wash pipe, uses the liner packer set inside the casing to isolate the casing annulus and has a slidable valve in the blank pipe below the packer, which is opened during gravel placement and is closed by rotation of the tubing after the gravel is in place. A port in the valve is isolated during gravel placement by opposed swab cups on the tubing or drill pipe, which seal inside the blank liner.

The washdown technique. The technique most commonly used in the coastal area, particularly with perforated casing, might be called the simplified or washdown technique (Fig. 6). Perforations are washed to obtain a cavity behind the pipe and to assure that the perforation holes are open. Gravel is squeezed through the perforation holes with a carrying fluid until the cavity behind the pipe is filled and reserve gravel remains within the casing. A screen and liner is then washed into position opposite the



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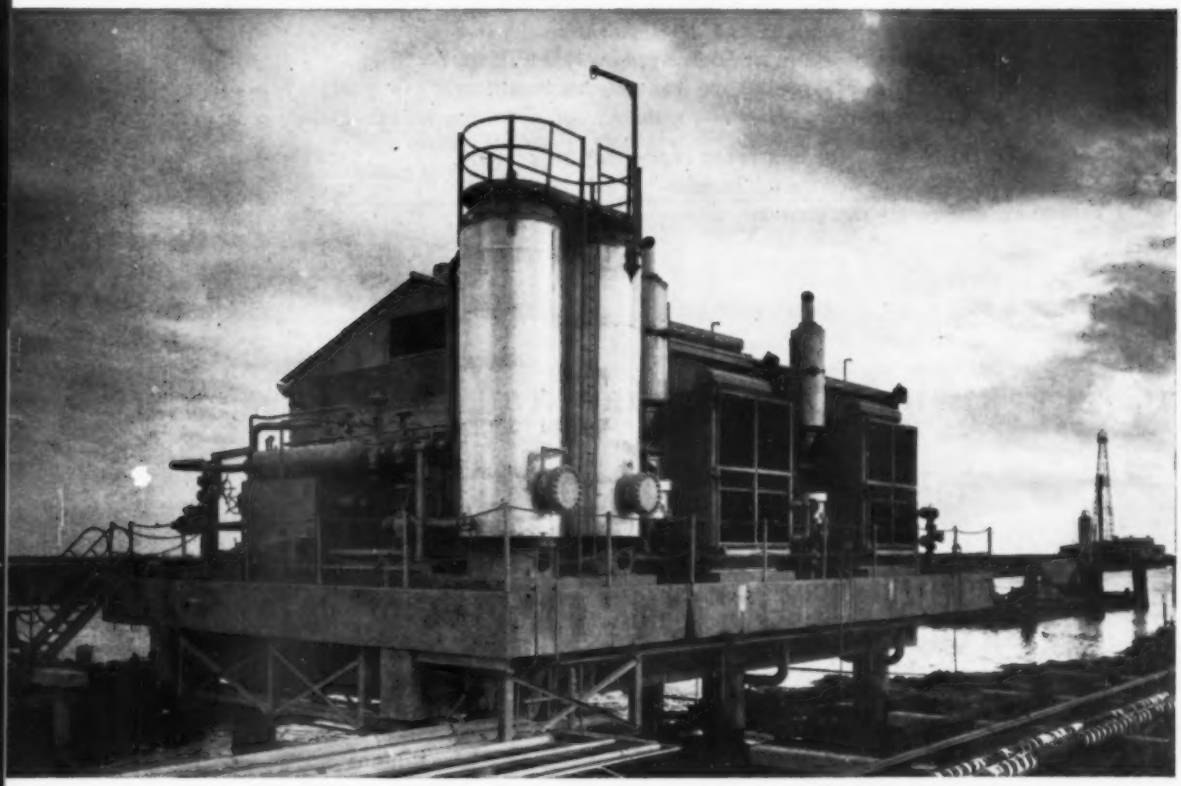

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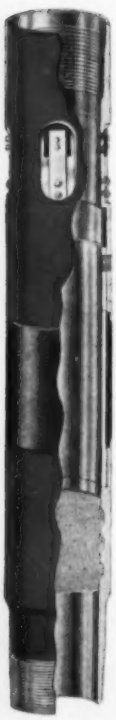

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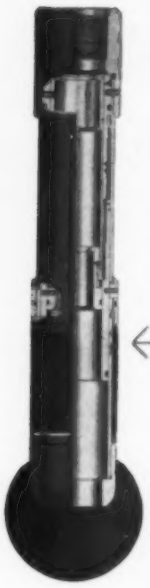

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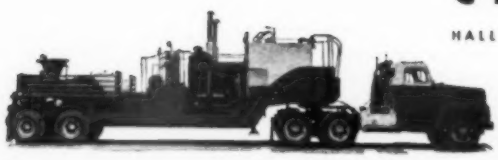

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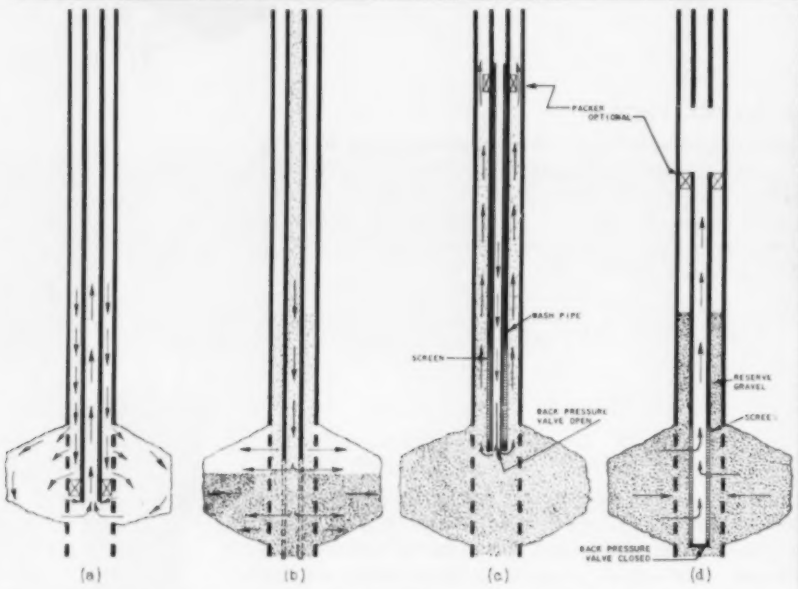

FIG. 6. Simplified method of gravel packing commonly used in the Gulf Coast. Perforations are washed (A), gravel squeezed through perforations (B), cavity filled and screen washed through gravel (C), and after screen placement, wash pipe removed (D).

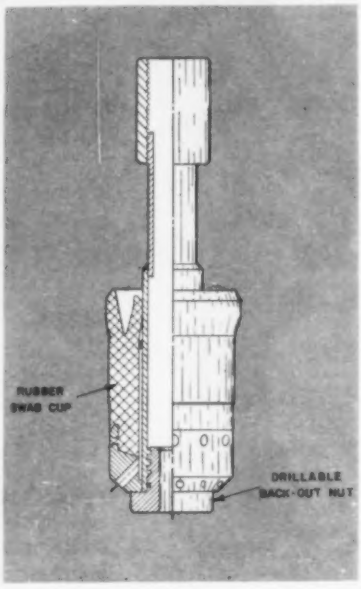

FIG. 7. Perforation wash tool used in the simplified method of gravel packing illustrated in Fig. 6 consists of a rubber cup and aluminum thimble placed on bottom of tubing.

perforations by direct circulation. After the gravel has settled into place around the screen, the tubing or drill pipe is released. This process has the advantage of maintaining flow into the formation and assuring that the cavity is full of gravel without allowing the sand or shale to slough or move. Washing the screen and liner into place has the advantage of grading the pack around the screen to remove any fine grains or debris in the gravel inasmuch as they settle back into place last and will not be in contact with the screen slots.

A perforation wash tool frequently used with this technique consists of a rubber cup with an aluminum thimble, facing upward, on the lower end of the tubing and held in place by an aluminum nut having a coarse left-hand thread (Fig. 7). Perforations are washed by reverse circulation so that sand and mud filter cake are carried up the tubing to the surface, thereby permitting removal with low fluid volumes in case of partial lost circulation and eliminating the hazard of sand bridging where the casing annulus is used as a return passage. The rubber cup with aluminum thimble and nut is removed from the tubing after perforation washing by applying pressure on the casing annulus and rotating the tubing or drill pipe which unscrews the nut and blows the very short assembly to the bottom of the well. Gravel may be placed by circulation down the tubing. As the gravel nears the perforations, the carrying fluid is squeezed into the formation, depositing the gravel in the cavity outside the perforations. After the necessary gravel has been deposited in the casing, the tubing may be removed and the screen and liner installed. This permits the entire operation to be performed with two trips of the tubing. Should a section of blank casing be present below the perforated interval, this section may be filled with gravel and the screen may be placed opposite the perforations and will remain in this position even without a liner packer.

The half-trip method. In some areas, such as offshore, it has been considered safer to gravel pack without making a round trip with water in the well. This is accomplished by the one-half trip method (Fig. 8). With this technique, the drillable perforation wash cup is attached to the back-pressure valve of the screen and liner (Fig. 9). The screen and liner is released by a T-slot safety joint requiring both rotation and compression. The wash pipe, extending from the tubing to the back-pressure valve and sealed in the tubing and back-pressure valve, may be retrievable with a wire line or permanently secured on the bottom of the tubing. If a production packer is desired in the final well installation, it is run on the tubing above the screen and liner and must have a blank mandrel and an automatic bottom that latches upon upward movement. Pump seating nipples or wire-line retrievable gas-lift mandrels may be located in the tubing string at their correct spacing.

The entire assembly is run with drilling mud in the well, and upon reaching the area immediately above the perforations the wash cup is tested by pressure on the casing annulus. The mud is displaced by direct circulation with formation water or weighted salt water. Direct circulation is possible around the rubber cup and through a by-pass.

Once the salt water is in position, the perforations are washed by lowering the cup into the perforated interval and obtaining reverse circulation. After the perforations are washed, the cup is removed by applying pressure on the casing and by right-hand rotation. Neither the screen and liner nor the production packer is released because the tubing does not move downward and is not in compression. Gravel is then placed in the well through the tubing and wash pipe that extends through the back-pressure valve.

The screen and liner is washed into position; and after the gravel has settled around the screen and liner, the liner is released by placing weight and right-hand torque on the tubing to disengage the slot on the releasing mechanism. The tubing is raised several joints, and the wash pipe may be retrieved with a swab line or may remain in place. The production packer is set by right-hand rotation in the conventional manner and the tree is installed, making the well ready for production. Oil or light water may be circulated into the tubing prior to setting the packer to elimi-

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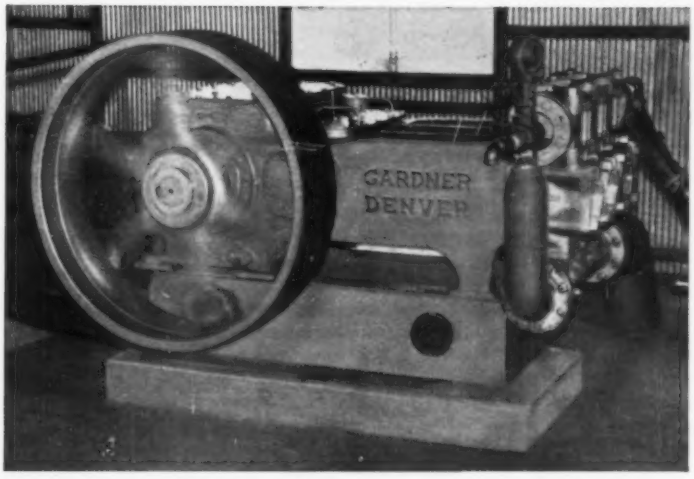

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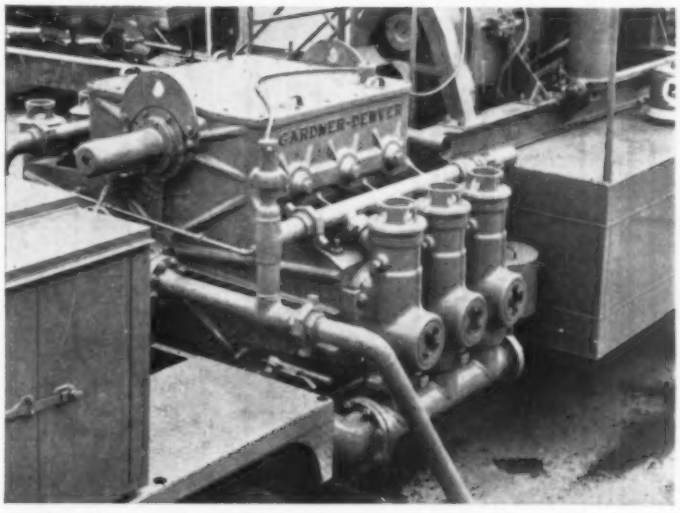

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nate swabbing operations. By this technique, wells as deep as 10,000 ft or greater may be gravel packed with the entire operation performed in 24 hours or less without ever removing the tubing from the well and permitting any chance of potential blowout.

The one-half trip gravel-pack equipment has been constructed to permit use of commercially available tubing-type perforators (Fig. 9). Use of this arrangement permits perforating after the gravel-packing equipment has been run and avoids contact of the new perforations with drilling mud.

Use of hanger and packer. With any gravel-packing technique, the liner hanger and liner packer may be omitted inasmuch as 25 to 40 ft of reserve gravel around the blank liner will act as a seal (Fig. 10A and B). Once a screen and liner is in place in the gravel, it will not move up or down, so that a hanger is not necessary for positioning. If there is doubt that the gravel will remain in position, a liner packer may then be beneficial because it permits the slotted screen to act as a conventional screen, stopping the production of sand after the gravel has moved or disappeared. This is particularly advantageous in cases where screens as small as 1½ in. have been used in gravel-packing intervals below collapsed casing or broken pipe when this is the largest screen that may be worked through the opening. In these cases, it is often considered that further shifting of the broken pipe may allow gravel to dislodge from its placed position. In gravel packing sidetracked holes very close to the original hole, there exists a possibility that communication may be obtained between the two well bores and the gravel may disappear by moving into the original well bore.

Gravel packing open holes. Gravel packing open holes frequently creates a problem when salt water is used as a circulating fluid inasmuch as the open-hole section may not remain intact with this type of fluid. It is often found that mud can be circulated from the well with water, and formation walls can be washed by using a bull plug with side jets on the bottom of the tubing. Gravel must be placed in the open hole as soon as possible to prevent the walls from caving, and the screen and liner then washed into place.

It is desirable to under-ream an open hole below the casing to allow several inches of gravel around the screen. Although blade under-reamers are often used, a hydraulic under-reamer has been found satisfactory and is particularly beneficial when water can be used because it aids in removing mud filter cake. The cross-over placement method is most commonly used in open hole when drilling mud must be utilized; however, it is imperative that this mud contain no sand. Once the well has been gravel packed, the screen and gravel are washed thoroughly with salt water by some wash tool such as a pressure washer or hydrostatic washer. Some development work has progressed on a gravel-packing tool that contains a blade under-reamer built into the pack-pressure valve that allows the open hole to be under-reamed and gravel packed with one trip of the tubing.

Water channeling. If a well has produced sufficient sand to create a channel into the water zone or gas zone, gravel packing will generally reduce the ratio inasmuch as it fills this channel with gravel. In some cases, water production has been completely eliminated after gravel packing, probably because loose sand obtained while washing the perforations is forced into the channel and seals off the water zone. If the formation sand face is completely clean and is in communication with the well bore through highly permeable gravel, the effects of gravity also may be sufficient to reduce water production, particularly if the water is located some distance from the perforations. Gravel packing prior to excessive sand production is an excellent means of preventing eventual ratio problems resulting from the creation of channel.

Shale sloughing. Gravel packing will maintain the shale

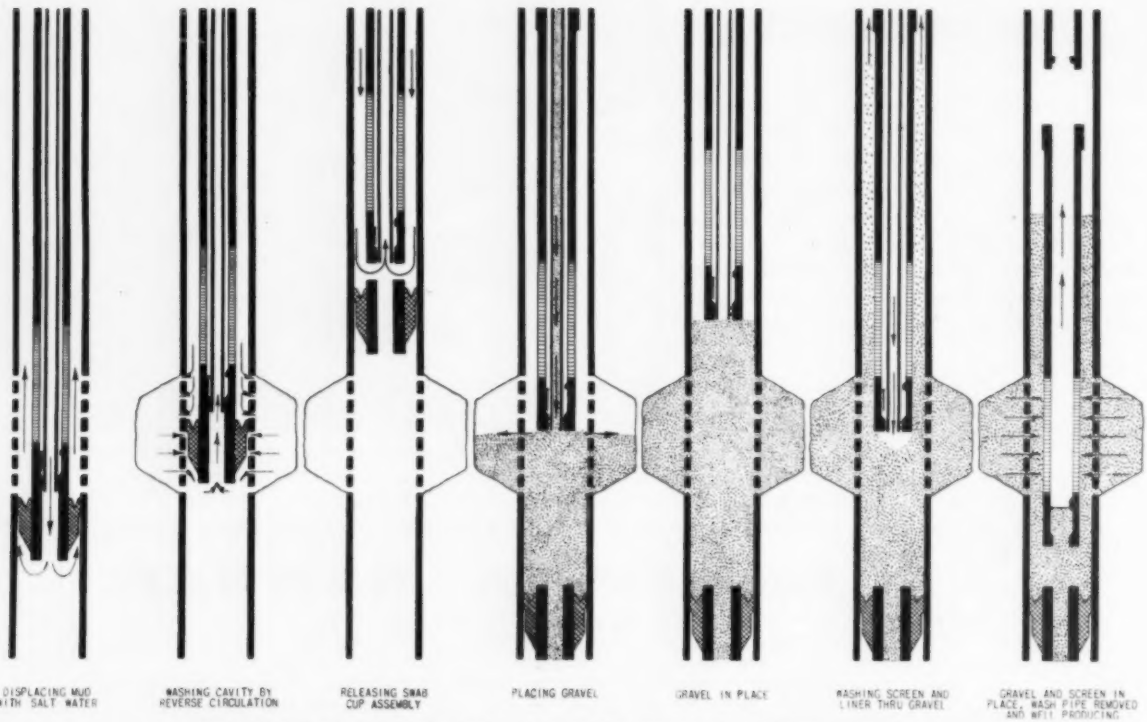
DISPLACING MUD WITH SALT WATER
WASHING CAVITY BY REVERSE CIRCULATION
RELEASING SWAB CUP ASSEMBLY
PLACING GRAVEL
GRAVEL IN PLACE
WASHING SCREEN AND LINER THRU GRAVEL
GRAVEL AND SCREEN IN PLACE, WASH PIPE REMOVED AND WELL PRODUCING

FIG. 8. Half trip method of gravel packing used in areas, such as offshore, where it is considered safer to gravel pack without making a round trip with water in the well.

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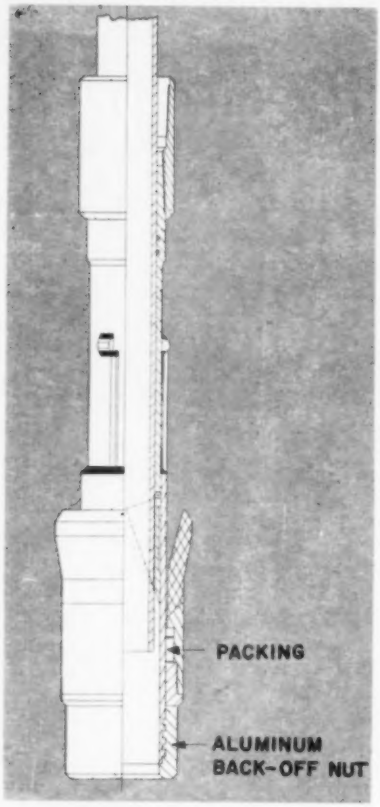

FIG. 9. Drillable perforation wash cup and back-pressure valve used as lower section of one-half trip tool.

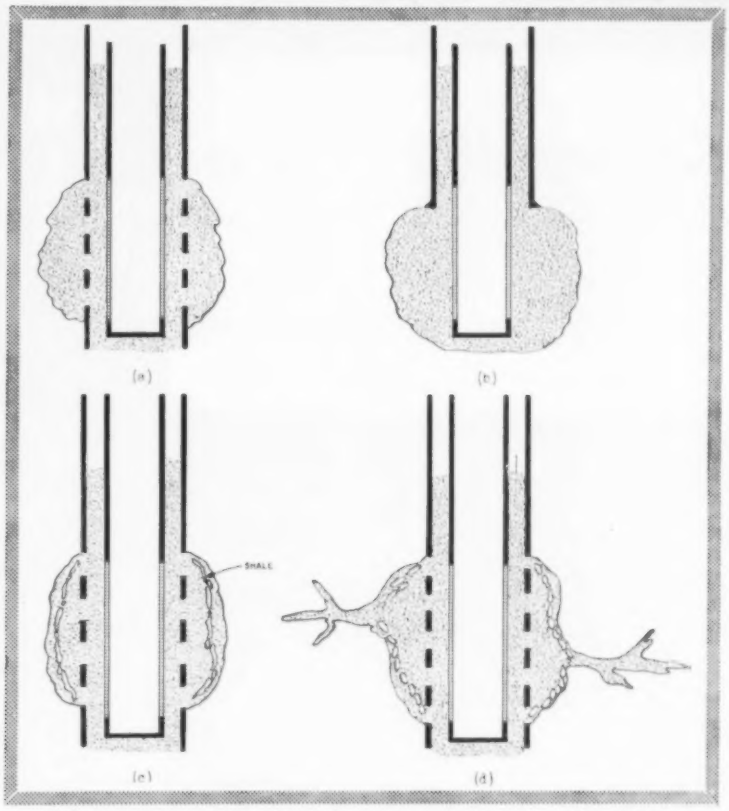

FIG. 10. Four gravel packed installations for particular well problems. In (C), shale-blocked gravel pack may be prevented or minimized by (D), pressure pack.

and sand in their correct positions and prevent shale sloughing against the screen or perforations that will lower productivity. If a well has produced sand and if shale blocks the casing perforations (Fig. 10C) or has formed a tight bed around the screen in open hole, it is preferable to gravel pack with placement pressure or squeeze pressures that are sufficient to obtain fractures so that a path of production may be obtained through the shale barrier (Fig. 10D). A fracturing job is performed until the formation will receive no more gravel, and a screen and liner is positioned in the reserve gravel opposite the perforations or in the open hole.

Remedial packing. Gravel packing can satisfactorily be performed inside screened open holes or perforated liners as small as 4 in. by using 1½-in. slotted screen. This screen, as the larger ones, contains centralizing lugs that center the screen in the liner. A faulty screen or slotted liner inside of open hole or perforated pipe should be perforated approximately one shot per foot prior to gravel packing to permit a means of placing the gravel through the original screen. When an old screen is located opposite perforated casing, the screen is frequently washed with a perforation wash tool after perforating and prior to gravel packing to remove the sand located between the old screen and the casing wall.

Packing without circulation. Gravel packing of formations is easily accomplished where circulation cannot be obtained. Gravel may be placed by pumping salt water or penetrating fluid with gravel into the well. When washing the screen and liner into position, it is often necessary to stop after each connection is made and allow the fluid level in the casing to lower before commencing pumping operations by direct circulation to wash down the next joint. If the screen and liner can be washed into position without making connections at the surface, sufficient circulation in the casing can generally be obtained once the cavity has been filled with gravel. As much as 200 ft of perforated interval has been gravel packed and the screen washed into position when no returns were obtained at the surface, and over 250 ft of open-hole section in limestone areas has had a screen washed into position with no circulation. In these limestone areas, the gravel packing of open hole was used as a means of preventing formation caving where nitro shooting was previously used for well stimulation.

Use of wire line tools. Gravel packing also has been accomplished without a rig using through-the-tubing tools. A steel 1¼-in. nominal-size screen was washed into place while suspended on a wire line. Although the job was successful in stopping sand production, and the well productivity was equal to the offset well gravel packed with a rig, the technique exhibits limitations when the perforations are a great distance below the end of the tubing.

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Concluding Part 2 of "Sand Exclusion in Oil and Gas Wells" will appear next month.

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Know the answers to these 10 questions? Try them!

1. Operating management can be held responsible for blowout prevention in what two important ways?

2. Do you know why, contrary to popular belief, a major share of controlling a well is on the driller and crew — not the toolpusher?

3. Do blowouts occur more frequently from deeper or shallow zones?

4. A sizable portion of blowouts happen in wells with normal pressurized formations at a time when the mud is of sufficient weight to control such formations. Is the figure nearest 35%, 50%, or 65%?

5. In what phase of the drilling cycle do most blowouts occur?

6. Most well blowouts are caused by: (a) Insufficient drilling fluid density, (b) failure to keep the hole full of fluid, or (c) reduction in static pressure due to swabbing action caused by drill pipe withdrawal?

7. Out of the hands of the crew on tour are several "secondary" reasons for blowouts. One reason stands out above all the others; which is it?
   a. Improper surface fittings,
   b. Insufficient blowout equipment,
   c. Improperly designed equipment,
   d. Improper installation,
   e. Improper well casing program and cementing practice.

8. Name one good device used to determine when a well is starting to kick.

9. What should be installed on diesel engines to prevent them from "running wild" and burning as a result of gas being drawn into air intakes?

10. On drilling barges and offshore platforms, vent lines should be run to opposite sides of the structure and vented in what direction?

You left a few of the questions unanswered? You'll find the answers on the next two pages — plus many aids and tips for effective blowout control and some startling facts about blowout causes. Read it thoroughly.

Do you know enough about BLOWOUTS?

An examination shows that men involved in drilling were directly responsible by their actions or not thinking for 60 percent of the wells that blow out!

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IN REPORTS from over two-thirds of the people operating drilling rigs, we find that drilling crews in general do not analyze the basic cause of blowouts, nor exercise sufficient vigilance. The really successful job of blowout prevention in done by rigid mud control and extreme care while pulling drill pipe from the hole.

The best blowout preventer equipment is useless unless the auxiliaries are adequate and ready for full capacity operation.

Requiring frequent periodic inspection and authorizing necessary repairs cannot be overemphasized. Some of the inspections must be assigned to the crew who then assumes the responsibility for thoroughness of the inspections and for making certain that the driller or toolpusher is completely informed of any doubtful or bad conditions found in the equipment. Neither the ruggedness nor the outward appearance of the control equipment should be permitted to affect the inspector's judgment. A fresh coat of paint may cover a preventer unit which would fail to work when needed. Any delay in making repairs on vital equipment can result in its failure to operate at a time when most needed. The old adage that a stitch in time saves time also has its application in the oil field.

Inspection and repairs can usually be made during periods where drilling operations are interrupted, such as waiting on cement or moving from one location to another. However, if it becomes necessary to suspend drilling to inspect and repair doubtful equipment, the loss of footage involved would be offset by the assurance that the equipment would perform when required to do so.

Management assumes full responsibility for *(Answer to Question No. 1) (a)* informing toolpushers and drillers with the best available engineering forecast of the potential trouble spots and *(b)* provides a casing program adequate for the requirements of the area. It is an elementary fact that a good casing program reduces the increased hazards of an exploratory well and is a matter of good business as well as a safety factor for those who drill the well.

Training in Safety

Training in the prevention of blowouts should begin with the crew having a good understanding of the various types of mud, including periodic reviews on combining weighting materials and chemicals. If with this foundation a blowout threatens, the secondary line of defense will be the alertness, teamwork and skill of the drilling crew in using equipment to control the situation. Every crew member must be assigned definite duties in connection with the use of the equipment and rig, and should receive instructions if required in the reasons for and timing of its use.

There is no substitute for actual practice and this should be done at frequent, stated intervals. These practice sessions not only will give the roughneck the "feel" of the equipment, and the feeling of the team effort, but also gives the equipment the frequent tests which are necessary to disclose faulty operations. When a blowout comes, quick action is necessary to prevent it and, therefore, practice sessions must be fully and seriously executed. This will help eliminate the confusion which results from the stress and excitement of an impending blowout by teaching confidence in equipment and in each member of the crew.

Drilling crews are assigned some of the responsibilities and assume many others for the prevention of blowouts by their presence on a job. A major share of the job in controlling a well is on the driller and crew because a review of the past blowouts show that in most cases the toolpusher was not at the well when the first warning of trouble came. *(Answer No. 2.)*

Blowouts from shallow sands happen more often than from deeper sands because they give warning for a shorter period of time during which blowout equipment can be operated. *(Answer No. 3)* and the safety factor in the mud column is reduced to fewer feet of head against the formation pressure. Once out of control, the chance of regaining control of a shallow blow is further diminished because blowouts at shallow depths generally do not bridge themselves, but instead tend to crater.

When the blowout preventer assembly is installed, it should include a thorough tightening of every nut in connection, tying down the flow line, bracing and turn buckling the assembly to prevent shaking or vibration, connecting choke manifolds, and installing remote controls so that the assembly will be ready for any emergency. Hand operated control valves should be conveniently located.

After the blowout preventer is properly installed it should be worked to make sure that the rams function properly.

Causes of Blowouts

More than 50 percent of the blowouts occur on wells which contain only normal pressured formations and the weight of the mud in use at the time of the blowout was heavy enough to control normal pressured formations. *(Answer No. 4.)*

Most blowouts occur while a trip is being made. *(Answer No. 5.)*

A study of 55 well blowouts over a 10-year period gave the following

Presented at the Texas Safety Association's 19th Annual Texas Safety Conference, Dallas, Texas, March 17-19, 1958. Drilling Safety Section arranged by the American Association of Oilwell Drilling Contractors.

Can you know too much about Blowouts?

causes as being the primary reason for the wells blowing out. *(Answer No. 6.)*

1. Failure to keep hole full of fluid 42%
2. Insufficient drilling fluid density 15%
3. Reduction in static pressure by drill pipe withdrawal swabbing 16%
4. Reduction in fluid levels by lost circulation 22%
   (Probably failure to fill hole and swabbing well in, rather than lost circulation.)

The same study showed that although the primary cause of the blowout was as shown above, the secondary reason or, why the well could not be controlled was as follows. *(Answer No. 7.)*

1. Insufficient blowout equipment 29%
2. Improperly designed blowout equipment 5%
3. Improper installation 11%
4. Improper well casing program and cementing practice 11%
5. Improper surface fittings 6%

An examination of this shows that men involved in drilling the wells were directly responsible by their actions or not thinking for 60 percent of the wells which blew out.

Here is a quote from a supplier of blowout equipment:

"In our observation of our customer's experiences, we think that 95 percent of the wells which get away do so as a result of two things. First, poor maintenance and inadequate testing programs result in leaks which cut out the assembly, and second, inadequate crew training results in non-use or misuse of equipment."

Pit Level Indicator Devices

When drilling in high-pressured formation it is essential that some means of measuring and recording the mud level in the mud pits be used. Some of the reasons for needing a pit level indicator *(Answer No. 8)* are as follows:

a. To know when a well is starting to kick as indicated by an abnormal increase in pit level which shows that oil, salt water or gas is entering into the mud system and that counter-measures should immediately be undertaken to get the well under control. Bringing the well immediately under control will prevent: First, the possibility of a blowout; second, excessive contamination of the drilling mud by oil, salt water or gas; third, eliminating the necessity of holding high back pressure on the exposed formation which could result in breaking down of the formation and loss of circulation, and fourth, less chance of sticking the drill pipe.

b. When making a trip, a driller can see that his hole is properly taking or displacing mud.

c. Indicates that lost circulation is taking place and prevents pumping away large quantities of mud before taking corrective action.

d. Assist in bringing a well under control after it has started to kick.

Suggestion

One company has this procedure to make sure the driller watches the pit level recording instrument: Once a tour the toolpusher is to go to the pit and either pushes the recorder float down or lifts it; he times the reaction of the driller, as to how long it is before he notices something is wrong. That is recorded on the chart.

Safety Measures

Measures to take which will reduce the hazards of fire:

1. The electric lighting system should be vapor proof. Lights around the shale shaker and flow line should be well protected so that they can't get broken and start a fire or explosion.
2. All open fires around a power rig should be immediately extinguished when a well starts to kick or when making a drillstem test. On a steam rig it will depend upon which direction the wind is blowing and how much gas there is before deciding to put out the fires under boilers.
3. No smoking around a rig when the well is kicking or when making a drillstem test.
4. Cars, boats, and fire arms should be kept at a safe distance from a kicking or blowing well.
5. The air intakes on diesel engines should have a position cut off as a diesel engine will run wild and will burn if gas is drawn into air intake. *(Answer No. 9.)*

Blowout Drills

A toolpusher should have regular blowout drills to insure that each member of the crew knows what is taking place and what his job is in case of a kick or blowout. Any new member of a crew should be told what his duties are in case of a kick or blowout and to participate in a blowout drill to insure he has been properly instructed.

He would rather have a crew who was well instructed and a poor rig, than a good rig with what he called a poor crew—or a crew that did not know what to do when trouble comes.

Miscellaneous Safety Measures

1. Vent and choke lines should be well secured or tied down. As these lines are often subjected to extreme high pressure, it is necessary that they be tied down to prevent their flying around and hurting someone or starting a fire. On drilling barges and offshore platforms, vent lines should be run to the opposite sides of the structure to be vented downwind. *(Answer No. 10.)*
2. In order to prevent hurting someone seriously and damaging equipment, particular care should be taken when changing and nippling up blowout preventers.
   (a) Several people have been killed when blowout preventers toppled over, owing to the placement of the chain or cable when picking them up. The preventer is extremely heavy and care should be taken to latch onto the preventer assembly high enough to prevent it from toppling over and pickup line should not be released until it is bolted in place.

Good, well kept equipment and well trained crews will prevent 95 percent of uncontrolled blowouts. * * *

PUBLIC TANK FARM: New Idea in Storage

A new storage and distribution tank terminal has been constructed in Memphis, Tennessee. The tank farm, located on the Mississippi River, is unique in several ways. It is believed to be the first to make accumulation and distribution facilities open to distributors, manufacturers and shippers on a lease basis. It is unique, too, because the tanks being constructed are for various products ranging from heavy crudes, to molasses, liquid fertilizers, chemicals, vegetable and animal oils, and petroleum jelly.

The "public" tank farm idea is that of the Memphis Mixed Products Terminal, Inc. The facilities are located on an 11-acre site in Memphis Harbor on President's Island. Rail, barge, and truck line services, in-bound and outbound, are available right to the tanks. Most tanks already constructed accommodate about 600,000 gal of liquid, each built to lessee's specifications.

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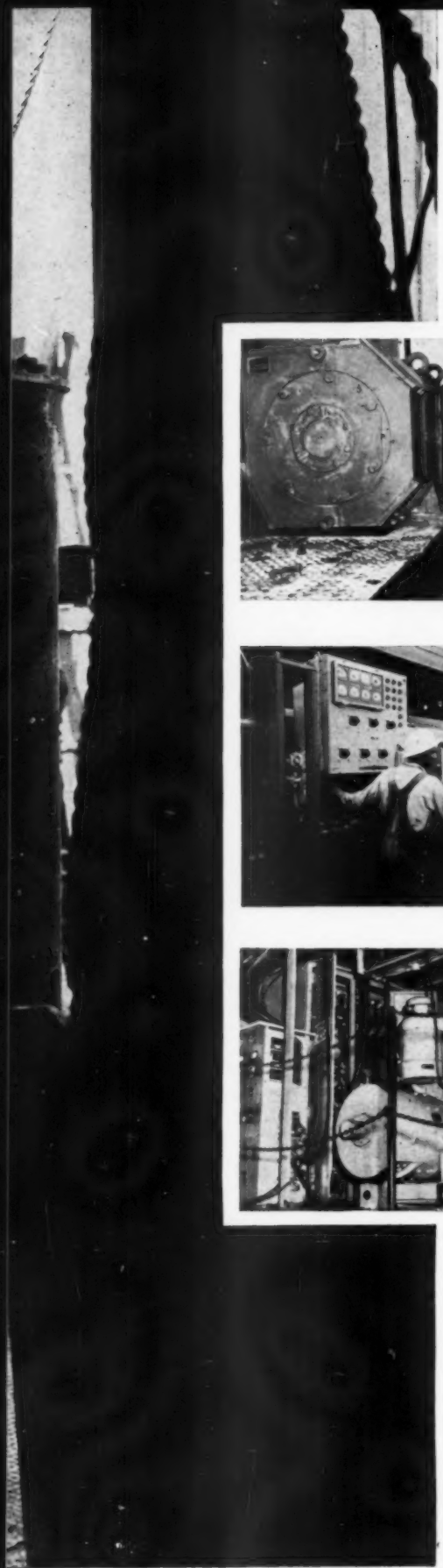

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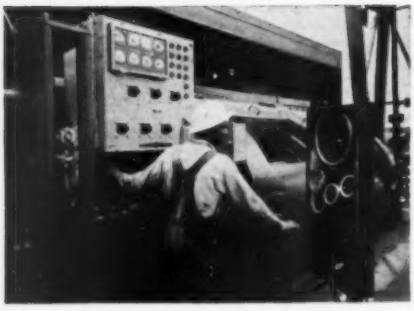

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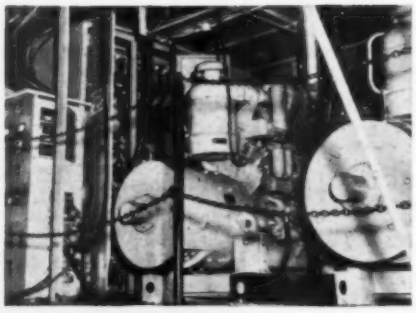

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The Discovery of the Johns Field

Here's the first-hand story of the search which resulted in the discovery of the Johns (Hockley) field in Duval County, Texas . . . one of the most significant, if not largest, finds for South Texas in recent years

T. E. Peeler,
Consulting Geologist,
Corpus Christi, Texas

THE JOHNS FIELD is located in northeastern Duval County, Texas, 11 miles due south of the junction of Duval, McMullen, and Live Oak counties. This tri-county intersection is formed by the southeast corner of McMullen County with the southwest corner of Live Oak County and a point on the north line of Duval County six miles west of its northwest corner.

The field lies 10 miles northwest of San Diego, county seat of Duval County, and is 13 miles southeast of Seven Sisters field on the old San Diego-Seven Sisters road. Fig. 1 is a map of the general area with the dashed line representing the regional strike of the Hockley formation. The Johns field is at the southwest end of this line and the West Cosden field is at the northeast end. Southwest Ramirena is slightly south of the center of the map and is east of the Hockley strike.

Regionally on the Hockley formation, the Johns field is approximately 1300 ft updip from the Southwest Ramirena field in Live Oak County and on strike with the West Cosden field in Bee County. Locally, Johns field adjoins Fitzsimmons field to the east, and Bridwell field to the southwest. The Southwest Ramirena and West Cosden fields produce from graben structures similar to the Johns field.

History of Discovery

Luck played a very important part in the discovery of the Johns field. Prior to the discovery, I had concentrated my efforts in the Jackson trend mapping the larger oil fields of the trend, hoping to find an undrilled field location or new sand on the known anomalies.

Fortunately, I found what appeared to be an undrilled location in the old Fitzsimmons field in Duval County. The up-to-the-coast fault which controls production in the Fitzsimmons field traversed diagonally across the southeast corner of an open tract of acreage a sufficient distance from the southeast corner to justify an additional location for the Pettus sand in the field.

The map in Fig. 2 is in the Fitzsimmons field area, Duval County, with contour lines on top of the Pettus sand. The outer pair of heavy dashed lines represents fault traces at Hockley depth and the inside lines are fault traces for the Pettus. The east fault is the up-to-the-coast fault which controls Fitzsimmons field production and the down-to-the-coast fault on the west forms the western boundary of the Johns field.

The small cross-hatched triangle of acreage in Fig. 2 encloses the proposed well site. It was on this premise that the first acreage was acquired. Further investigation disclosed oil shows in the Richardson No. 1 Mew well located in the graben west of the Fitzsimmons field. Location of this test is on the fault trace just southwest of the above-mentioned triangle of acreage. Sand present in the interval from 3436 to 3566 ft in the Richardson well contained an oil show. In a 15-minute drillstem test from 3470 to 3566 ft through ¼-in. and ⅜-in. chokes, the tool slipped to 3482 ft.

Maximum working pressure was 8 psi and recovery was 220 ft of mud cut with oil. An electric log was not run on this well. However, a plotted driller's log indicated the bottom seven feet of section tested to be the upper Hockley sand which is blanket in the area.

The Richardson well was drilled to a total depth of 4336 ft and plugged as a dry hole. Correlation of the driller's log indicated the Pettus sand to be faulted out. Using an estimated Pettus sand top from the driller's log and several estimated down-thrown Pettus points from electric logs on wells in the Fitzsimmons field, it appeared that a closed structure could exist in the graben area west of the Fitzsimmons field. This theory was supported by the oil test in the Richardson well from a blanket sand.

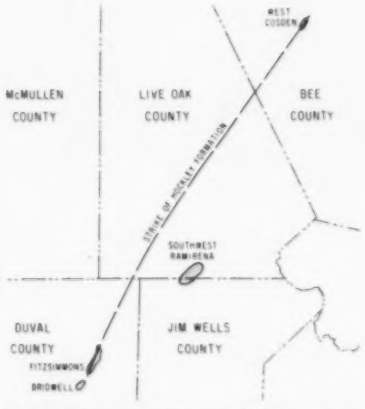
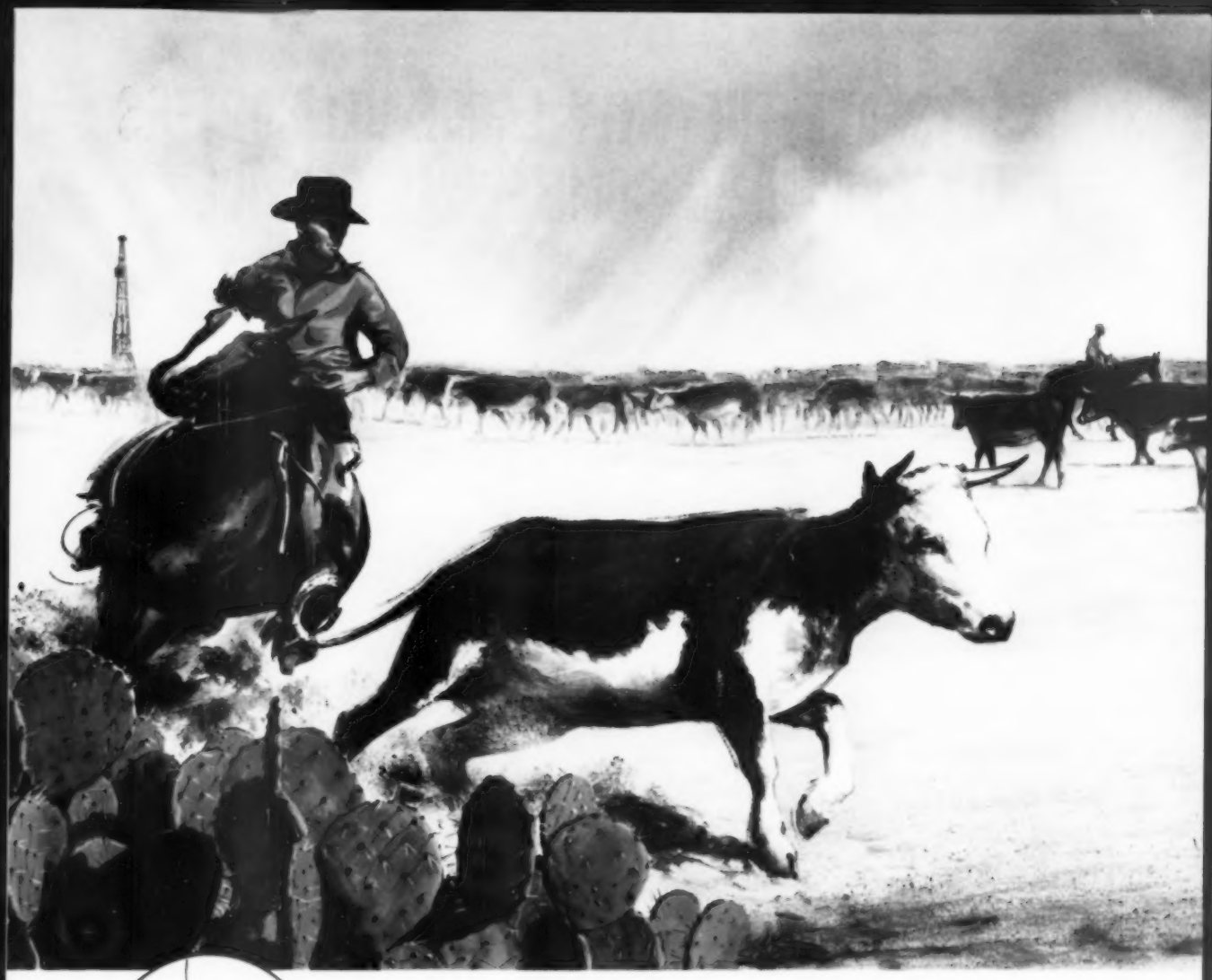


FIG. 1. **General view** of South Texas area including the strike of the Hockley formation. The Johns field joins Fitzsimmons field to the east and Bridwell field to the southwest.

Fitzsimmons field production was established in two formations: The Pettus, which was oil-productive in four string sands, and the Hockley, which was gas-productive from one sand. Cumulative oil production for the

T. E. Peeler *was born in San Antonio, Texas, in 1922 and has resided in Texas all his life with the exception of three and one-half years spent in the armed services during World War II. He is a graduate of Texas A&M with a degree in geology. Since his graduation in 1948, he has been located in Corpus Christi, Texas. He has been employed by the Chicago Corporation, Seaboard Oil Company of Delaware, F. William Carr, independent, and formed the Coastal Trend Oil and Gas Corporation with three other individuals. He is presently employed by A. C. Sien, Jr.*

Based on a talk delivered by author to the Corpus Christi Geological Society, February 1958.



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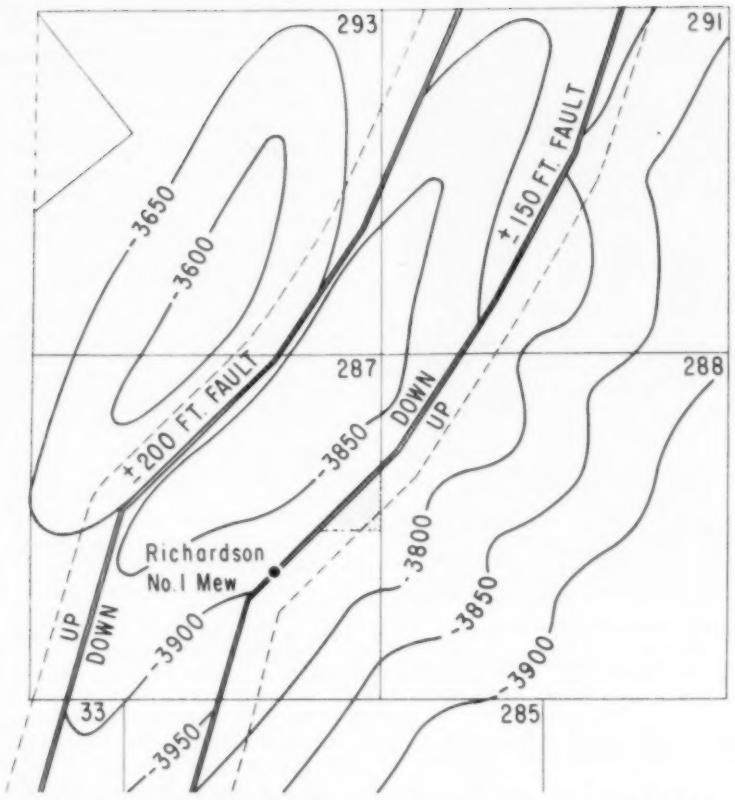


FIG. 2. **Fitzsimmons field area,** with contour lines on top of the Pettus sand. The outer pair of dashed lines represents fault traces at Hockley depth and the inside lines are fault traces for the Pettus sand. Discovery well was located in area represented by small cross-hatched triangle.

field was 5,050,022 bbl as of January 1957, and present annual production is approximately 63,000 bbl.

The Pettus sand was assumed to be the primary objective of the graben prospect since it was the principal producing sand across the fault in the Fitzsimmons field. To date, the Pettus is not producing in the Johns field. Apparently, there is no effective closure at Pettus depth.

The discovery well in the Johns field was drilled at a location near the center of the graben and opposite the central part of the Fitzsimmons field. This discovery created a wild scramble for additional acreage which was available.

Reservoir Data

Core and test results in the discovery well indicated two Hockley oil sands and five probable gas sands above and below the Hockley. The Johns field produces oil from a depth of approximately 3500 ft from the upper and lower Hockley which appears to be one sand body on the electrical log, a part of which appears in Fig. 3. The upper Hockley is approximately 25 ft thick and is a very fine-grained, medium porous, gray sand. The lower Hockley is approximately 35 ft thick and is a coarse-grained, highly porous, gray sand. The two sands are separated by one to three feet of sandstone which is present throughout the area.

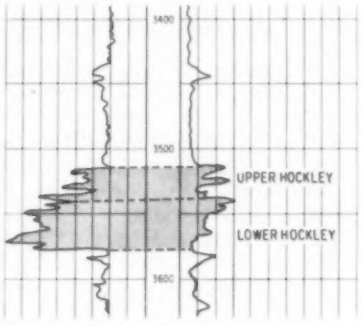


FIG. 3. **Portion of electric log** from discovery well shows upper and lower Hockley sands which are separated by one to three feet of sandstone present throughout the area.

The upper Hockley has an average of 1500 bbl per acre-ft of oil in place, with an average mobile reserve of 1000 bbl per acre-ft, estimated from core analysis. The lower Hockley has an average of 1900 bbl per acre-ft of oil in place with an average mobile reserve of 1200 bbl per acre-ft. The upper sand has an average permeability of 200 millidarcys and porosity of 33 percent. The lower sand has an average permeability of 1100 millidarcys and porosity of 37 percent.

Both Hockley sands have a gas cap, gas in solution, and, it is thought, an effective water drive. The estimated gas-oil contact for the upper Hockley is −3109 ft and the oil-water contact is at −3144 ft.

The lower Hockley gas-oil contact is at −3122 ft and the oil-water contact is at −3145 ft. Average bottom-hole flowing pressure for the Hockley zone is 1050 psi and bottom-hole shut-in pressure is 1350 psi.

Gas-oil ratios range from 250 through 550 to 1.

The Mirando, Upper Loma Novia, Government Wells, Argo, Cole, and several basal Frio sands are gas-productive and range in depth from 2100 to 4100 ft.

Mobile oil reserve for the entire field should be approximately 12 million bbl. Cumulative production from discovery in August 1956, through December 1957, is 298,161 bbl. The productive width of the field at Hockley depth is approximately 2000 ft and the length is approximately 3½ miles.

To date, there are 46 completed wells — 45 oil wells and one gas well. The southwest end of the field is delineated by dry holes which indicates a tilted water table. The oil-water contact in two dry holes at the southwestern extremity of the field is higher than the average contact in the field and there is no indication of fault separation. Also, the northeast end of the field has a lower oil-water contact.

Field Rules

Texas Railroad Commission rules require a minimum distance of 660 ft between wells in the same reservoir, a minimum of 330 ft from property or lease lines and one well to each 20-acre proration unit. Each well allowable is based 75 percent on acreage and 25 percent on total field allowable. Five hundred feet of surface casing is required unless a multi-stage cementing process is used, in which case 125 ft of surface casing is sufficient.

Sale of Products

Sinclair Refining Company markets the crude oil from the Johns field and their current price is $3.27 per bbl. Coastal States Gas Producing Company has contracted for the gas at 12.2 cents per Mcf and is presently in the process of constructing a line through the field.

Acknowledgments

I would like to thank Ernie Mulle, geologist with the La Gloria Corporation, for his kind and willing assistance in the preparation of illustrations and assembly of material for this paper.

★ ★ ★

Dry holes, which cost the industry about a billion dollars last year, illustrate staggering risks peculiar to oilmen. Above, crew members unceremoniously prepare to "abandon site" of Texas Gulf Coast duster and move to a new drilling location.

The HIGH COST of DRY HOLES

They've always been a problem — but not quite so expensive!

THE DRY HOLE is many things. To the geologic map-maker, it is merely a small circle transversed by a straight line. To the roughneck on the drilling crew, it is change of address. To the small wildcatter, it is disappointment, heartbreak, and all too often economic disaster.

To a company like Humble Oil & Refining, the dry hole is a perplexing paradox: Unavoidable, enormously expensive, yet necessary to the search for oil. Last year, dry holes cost Humble almost $62 million, roughly $13 million more than in 1956. But oil can't be found without drilling for it. And when you drill, the odds are strong you will find nothing.

In 40 years, the company has poured half a billion dollars down long, dry holes. That's nearly half as much as the company's total assets today. Just since 1933, Humble has drilled 3540 dusters averaging a mile and one-third in depth. End on end, they would probe two-thirds through the earth, or stretch from New York to San Francisco — via the Panama Canal.

Like nothing else, the dry hole tangibly and dramatically illustrates the staggering risks peculiar to oil hunting. It has been said of the oil business that if the gushers produce the romance, and dry holes the tragedy, there are few parts romance to many parts tragedy. All who drill for oil do not live happily ever after.

Loss A Certainty

American business is characterized by risks taken against odds in the hope of profit and progress. But risks in the oil-finding business are greater, and considerably different from those in other businesses. Little or nothing is recovered from the dry hole. In fact, the search for oil entails not so much a consideration of risks as it does the *certainty of loss.* The searcher cannot know how many losses he will sustain, how frequently they will come, or how costly each will be. But he can depend on losses due to dry holes.

He can also draw some sobering conclusions from the experiences of other oil hunters.

Only one in nine rank wildcats the industry drills produces oil or gas. Only one exploratory well in 44 finds a field that will produce a million barrels — enough to supply America a scant four hours. Anything smaller, the industry has found, is usually not profitable to produce.

Even after a field is found, dry holes continue to be a major headache. The only sure way to determine the field's productive limits is to keep drilling at locations farther and farther away from the discovery well. At this point, the oil hunter has mixed feelings: He dreads the dry hole, but is never satisfied until he hits one. One development or field well in four is a dry hole, but often the average is much higher. In one proved East Texas gas field, Humble drilled seven dry holes in 12 attempts.

Worse Than Dry

Aside from dry holes, marginal and even big producers are sometimes teasers, inducing owners to throw good money after bad. For example, back in March 1923, the spectacular Kosse gusher came in and for 36 hours spewed oil over the Texas countryside.

Eight days later, the freak well sputtered and stopped after flowing only 38,000 bbl of oil. But oil fever is contagious and impossible to quarantine. Almost overnight, Kosse's population increased by five-fold. Subsequent wells turned up either dry or with no commercial shows; today, the Kosse field is an abandoned, one-well field. Gas still bubbles from the black earth around the discovery well, but 29 dry holes sit in mute warning.

'Twas ever thus in the American oil industry. Ancient petroleum records show that not one, but two wells were drilled in the historic year 1859. One, of course, was the famous Drake well at Titusville, the birthplace of the industry. Ironically, the other well was bone dry. Nobody seems to recall where or by whom it was drilled.

The Sad Trend

Today, 99 years and a million and a half wells later, the oil man still is drilling dry holes with rueful regularity. Dry holes cost the industry about a billion dollars a year — almost 40 cents for every barrel of oil produced. Still more millions are lost on surrendered leases and unsuccessful exploratory work. Only about five percent of all acreage leased proves even mildly productive. In all, about half of all the money spent on exploration and drilling results in no production.

Reprinted from the March-April 1958 issue of "The Humble Way," employee publication of Humble Oil & Refining Company, Houston, Texas.

As if the sky weren't bleak enough, new storm clouds have been gathering on the lip of the horizon, especially in the past 10 years. Dry hole frequency has been inching up. Dry hole costs, on the other hand, have skyrocketed — almost to the point of jeopardizing the health of a natural resource industry, one essential to the nation's welfare and security.

These dry hole experiences reflect a reasonably accurate picture of the industry-wide problem. Over its 40-year history, this company has suffered about one dry hole in every four drilling attempts — rank wildcats thrown together with development wells in proved fields.

Dry hole frequency is geared chiefly to the amount of wildcatting in risky areas, and therefore fluctuates widely in different years. The firm's drilling average, if anything, has improved since the early years.

The dry hole cost picture is not so pretty. In the first 20 years of drilling, dry holes never cost Humble more than $3 million. By contrast, the company now has nine dry holes in the debit column that cost in excess of $1 million each.

Three of these were drilled in 1957. One, an offshore wildcat, had a good show of gas until Hurricane Audrey came and the hole was lost. Another was a 17,800-footer into the hard, hard crust of West Texas. The third, Humble's most expensive dry hole on record, was likewise on dry land — in the rugged foothills of California. Several other dusters — on and offshore — nudged the $1 million cost mark.

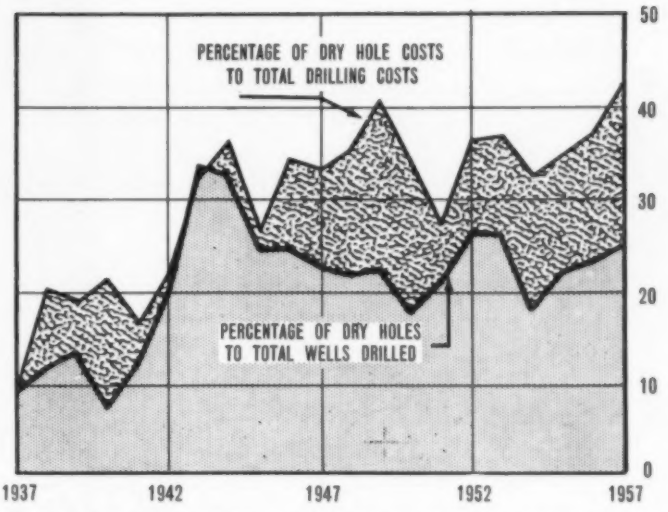
Because dollar values have been highly inconstant over the years, the most reliable measuring stick of climbing dry hole costs is their percentage of total drilling expenditures. The trend is clear. Dry-hole outlay in 1937, the company's all-time peak drilling year, represented only 10 percent of drilling costs. In 1957, it soared to *42 percent*.

Humble has not been as adroit at sidestepping dry holes as some companies, but more successful than most. In any case, its experience plainly indicates that dry hole costs have risen far out of proportion to dry hole frequency.

Why?

The "why's of pyramiding dry hole costs are many and complex. Some involve changing concepts in oil-finding; others are simple but substantial increases in cost of materials and labor. A few of the high costs can be curbed; many cannot.

For one thing, oil is getting increasingly tough to find. Gone is the easy oil in the shallow sands. Areas that would not have warranted a second look 10 years ago are good prospects today. Beckoned by the memory of the billion-barrel fields of yore, oil men have turned to places of difficult access: Jungles, mountains, deserts, arctic wastelands, and the open sea.



Humble's dry hole experience has been erratic, but getting worse. In 20 years, dry hole costs quadrupled from 10 to 42 percent of drilling expenditures. Dry hole frequency in 1937, the company's peak drilling year, was one in 10; in 1957, it was one in four.

Frontier drilling — such as Humble has done in the Louisiana swamps, Florida, California, the Gulf of Mexico, and now Alaska — is almost prohibitively expensive. But oil men are risk-takers, pure and simple, and the profit motive is strong. If they figure oil is trapped somewhere, they go after it.

Florida 'Graveyard'

Sometimes this pays off, but not always. Florida, for example, began to look highly promising back in 1943. The industry sank millions there but has found virtually nothing. Humble brought in the only commercial oil field, a small one, but also reaped a harvest of 38 dry holes.

Offshore in the Gulf, 75 companies have invested $2 billion in the search for oil. And still the total daily production is but enough to serve the nation 15 minutes. Here, drilling is generally conceded to be five times as expensive as on the land. Four wells in any one of several onshore Gulf Coast fields could be drilled for the price of one helicopter used to transport crews to offshore rigs.

Deeper drilling is another reason for rising dry hole costs. Twenty-five years ago, a 10,000-ft hole was considered deep: The first one, a dry hole in California, was in 1931. Today, several wells have probed the earth more than four miles. One of these, a 21,687-footer in Pecos County, is Texas' deepest and another dry hole. The depth of the average Humble-drilled dry hole 20 years ago was 4601 ft. Last year, this was almost doubled.

The Ante Rises

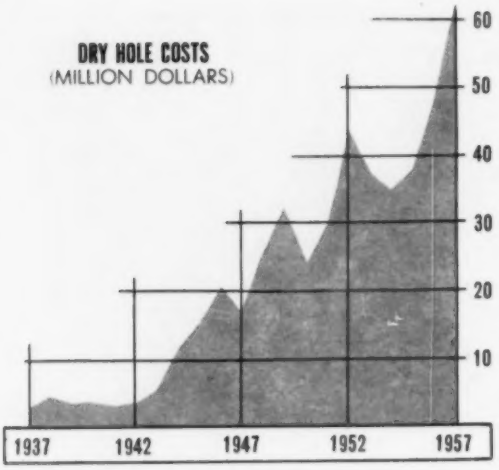
Deep wells require more time, bigger and heavier equipment, more and better muds and cements, and special safety precautions. Not only oil-finding tools, but oil-finding ideas are stretched well past their limits. All this costs handsomely — and the cost of deeper drilling is not merely greater. The deeper the well, the more the rate of cost is accelerated. For example, the normal drilling cost of an 8000 ft well is $14 per ft. For a 15,000-footer, this jumps to $35 per ft. The world's deepest well, in Louisiana, bottomed at 22,570 ft; it cost $110 for each 12 in.

Generally, the oil fields being found today are smaller, deeper, less accessible, and more complicated geologically than those found in earlier years. And Mother Nature assigns whole battalions of gremlins to the dry hole detail — high pressures, crooked holes, and weather problems to name a few.

Keen Competition

Leading oil explorers are warning that under present trends, the cost of finding U. S. oil may soon equal the value of the oil. In addition to deeper drilling in more difficult locations, they have in mind many other factors that are pushing exploration and drilling costs skyward.

Competition is keener than ever before for leases; farmers and ranchers get more for permits to explore on their land. Brainpower and scientific equipment are more expensive. Drilling trucks cost three times as much; dynamite is up 60 percent. Wages of workers in field crews on geological and geo-



Sharply rising dry hole costs of Humble Oil & Refining Company reached a record $62,000,000 last year. In the past 40 years, dry holes have cost the company half a billion dollars.

Increased costs of drill pipe, and other materials and equipment, coupled with higher wages for labor, have pushed drilling costs — and in turn, dry hole costs — skyward. Moreover, today's drilling is deeper, more complex geologically, and in more remote locations.

physical surveys have nearly doubled since World War II. Overall, exploration costs have doubled and tripled since 1948.

Tubular goods and labor cost 56 percent more than 10 years ago. Oilfield machinery like drawworks and blowout preventers are up about 60 percent. Drilling muds, cement, well services like logging and perforating — all are twice as costly as a decade ago.

How can high exploration and drilling costs — and in turn, high dry hole costs — be curbed?

Both economists and engineers believe that rampant dry hole costs could be partially controlled with a wider spacing of wells. Today's knowledge of reservoir behavior is so great, they insist, that wider spacing would allow for proper drainage of oil and at the same time make domestic producers more competitive in the world-wide petroleum industry.

One cost-control method Humble found expedient during the depression years was a more cautious selectivity of drilling sites. Only the bread-and-butter wildcats with better than average potential were sunk. The high-cost frontier areas were avoided. This, however, was a temporary measure. Today, no oil company can long survive unless part of its time and money is devoted to the long-shot — fields that might really pay off.

A more long-sighted approach to reducing dry hole odds and costs involves better trained men and an improved technology. New exploration tools and techniques, developed through research, whittle away at the risk and enhance the possibility of finding oil.

Similarly, efforts to control drilling costs result in better methods, materials, and equipment. Emphasis in the past decade has been on improved hydraulics, special drilling bits, and well services like formation fracturing. Emphasis in the next 10 years, drillers predict, will be on ultra-slim hole drilling. Reducing a hole from seven to two inches will result in tremendous steel savings in some wells. Humble is a leader in the slim hole movement.

Cooperative drilling allows companies to cut costs by spreading the risk. By one method, several major companies put up "dry hole money" to encourage a small independent to drill a test well in an area where they own leases. If the wildcatter hits, he has himself an oil well and the majors pay nothing. If he misses, the subscribers foot a predetermined portion of the bill.

Another share-the-risk arrangement sees major oil companies teaming up to move into an especially costly territory — such as Humble and Shell did last year in Alaska. Preparing for and drilling the Bear Creek No. 1 probably will cost nearly half as much as the $7 million the U. S. paid for the whole of Alaska back in 1867. Only through joint risk-taking was the venture possible.

Maligned as they are, dry holes are not completely worthless. They aid the search for oil by adding information to the storehouse of knowledge about underlying strata and by outlining the productive bounds of known fields. If nothing else, they show you where the oil isn't.

Sometimes, dry holes betray valuable underground deposits of other natural resources — sulfur, potash, water, brine, even helium. Seventy percent of the nation's uranium reserves were discovered in New Mexico when a gamma ray instrument was lowered into the depths of an unsuccessful oil well.

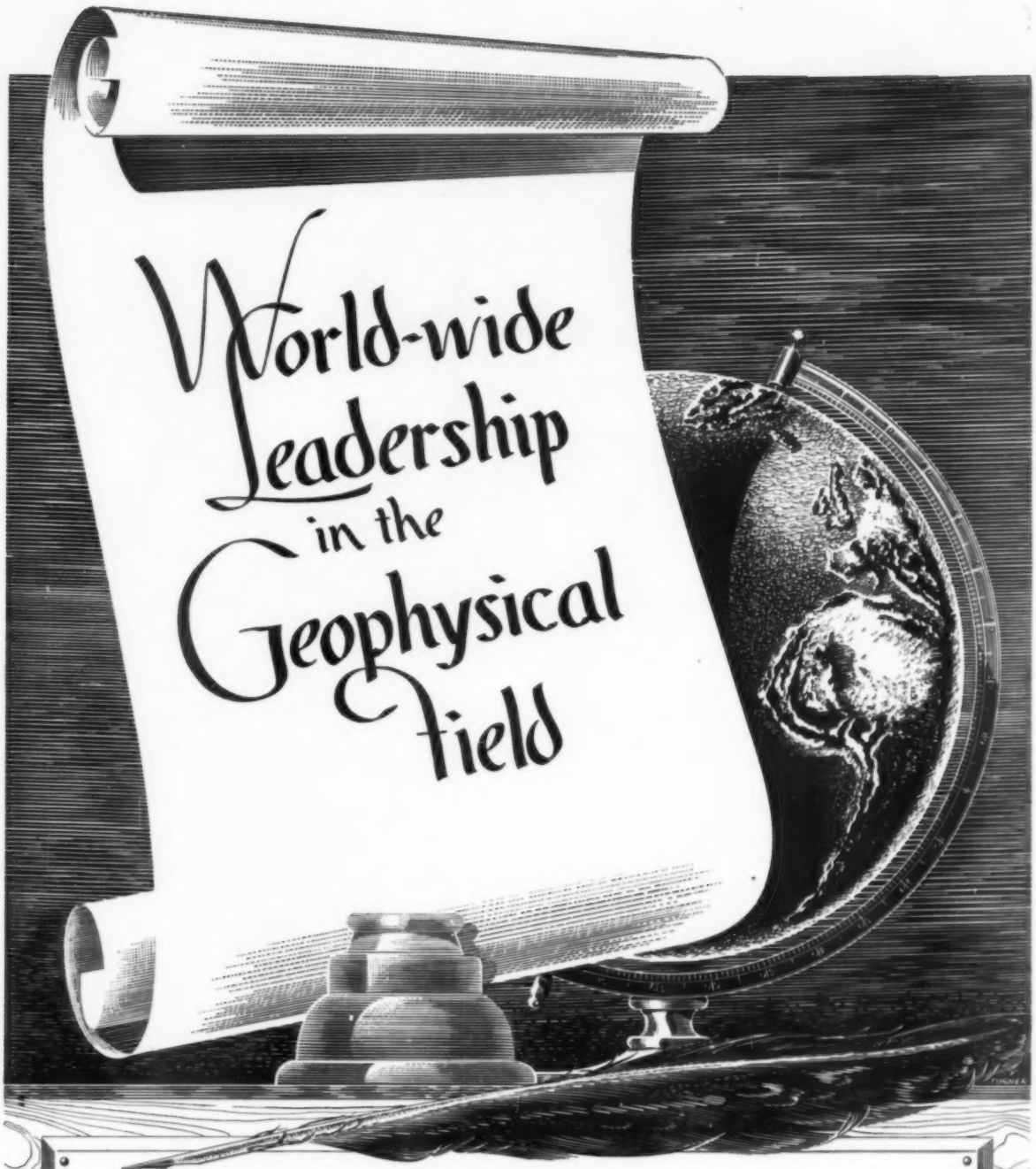
The dry hole, which represents the negative side of a positive-thinking industry, is here to stay. Long ago, the oil man learned to live with it. But behind the dilemma of the dry hole looms a more basic problem: The American oil man is finding less oil with each well. The rising costs of finding and producing oil have far outdistanced oil price increases. The returns are getting mighty lean for the great risks involved.

Incentives

Part of these enormous risks are offset by percentage depletion, which recognizes a unique fact about the oil business: An oil well dies a little each day. Finally it quits altogether — becomes depleted. But even the much-misunderstood percentage depletion, with 30 years of successful operation, cannot compensate for the low rate of return on investment that has been steadily declining.

The incentive that keeps oil men going is that age-old hope of hitting a jackpot — of making a large profit on some successful investment. More realistically, however, most oil men know that the prospects for this are becoming increasingly dim: Their basic hope is to get enough return on the few discoveries to offset the many losses, and still leave something to make the risky effort worthwhile.

The high cost of dry holes poses a serious obstacle to that hope. But America's oil men — most of them unwavering optimists — feel that under the proper economic and governmental climate, they can find many untapped domestic reservoirs and help keep the U. S. among the ranks of the self-sufficient oil nations of the world. ★ ★ ★



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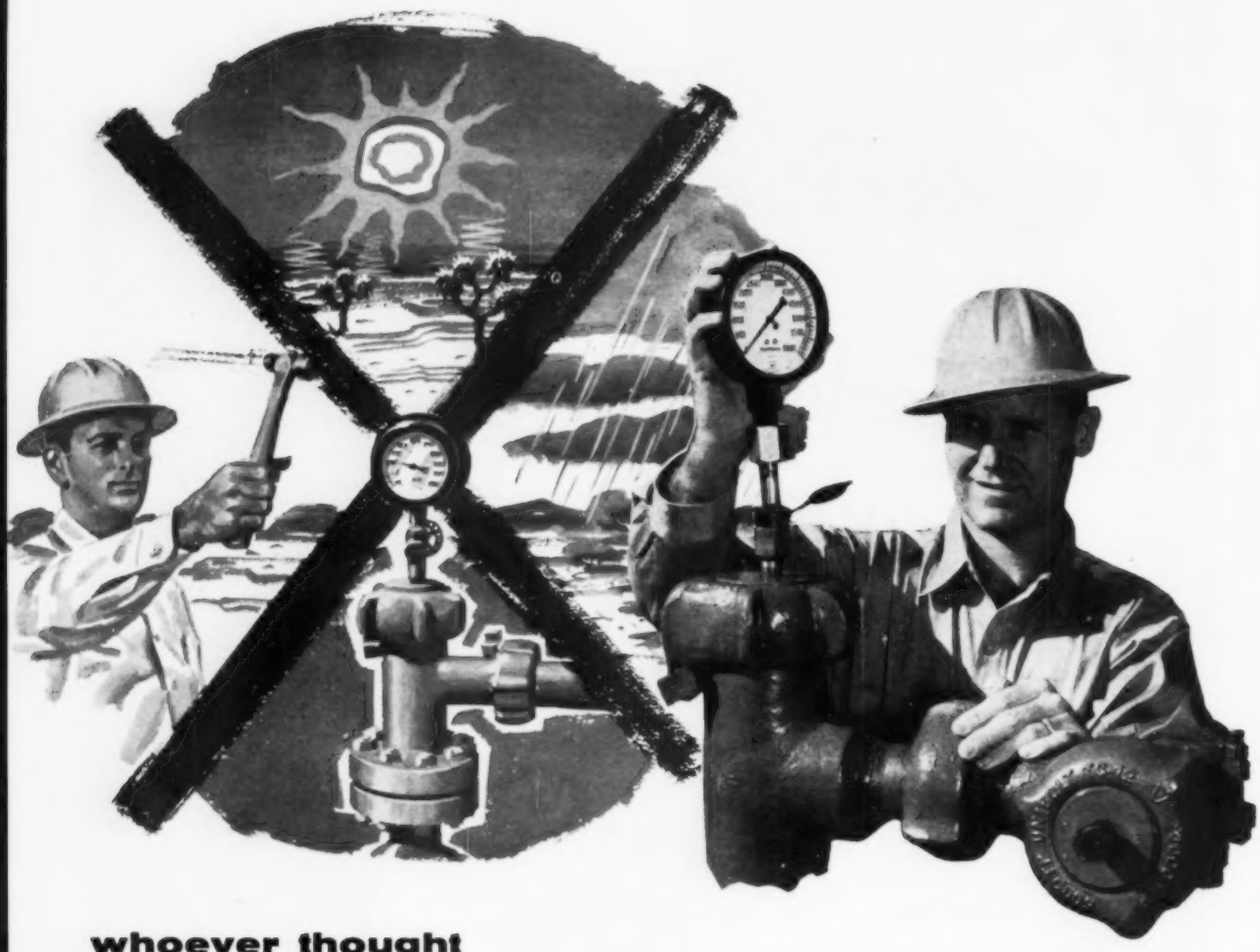

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Note in the cutaway view of the TC Gauge Valve and Connector at right how the Connector Element, to which the master gauge is attached, engages a J-slot in the Gauge Valve Element, opening a spring-actuated valve to expose the gauge to well pressure. The operation requires only a minute or two.

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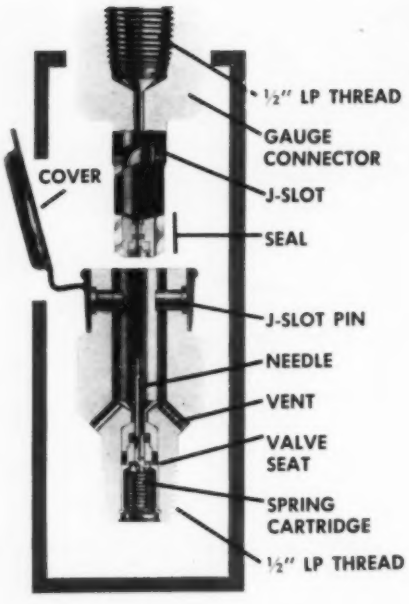

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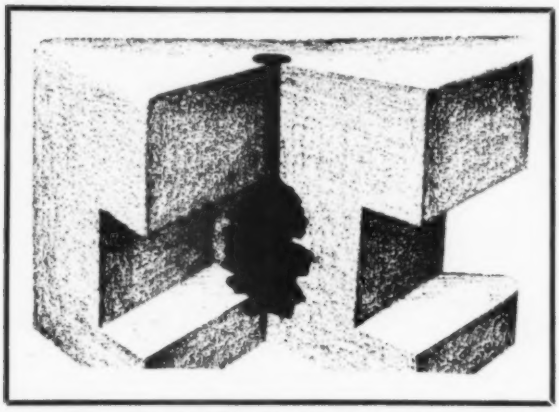

FIG. 1. **Conventional inhibited hydrochloric acid** dissolved out a hole as indicated in this drawing of a simulated bore hole in a limestone block.

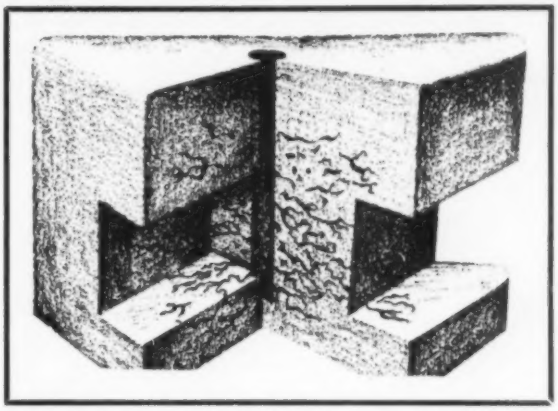

FIG. 3. **Action of retarded acid** to form extended flow channels radiating from the simulated well bore in limestone block is shown in this drawing.

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RETARDED ACIDS: New Well Stimulation Technique

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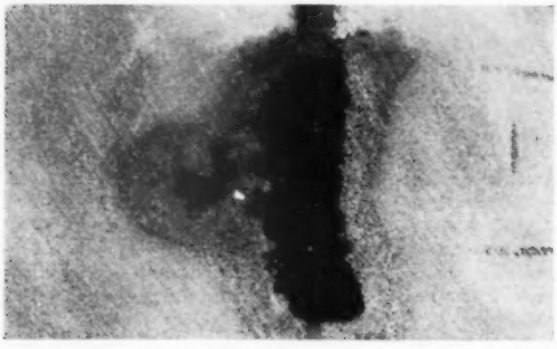

FIG. 2. **Actual cross section** simulated bore hole in a limestone block treated with conventional hydrochloric acid shows enlargement confined to vicinity of well bore.

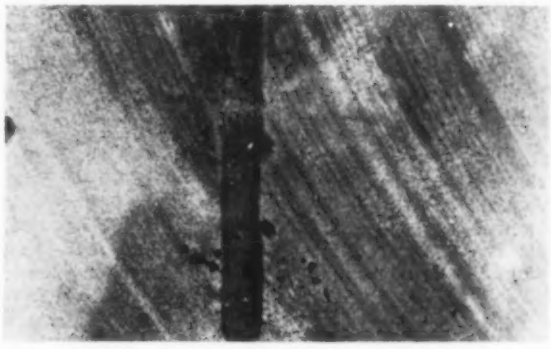

FIG. 4. **Photograph of simulated well bore** after treatment with retarded acid shows the extent of acid action in making flow channels some distance from the well bore.

A. W. Coulter,
Dowell Division of
The Dow Chemical Company,
Tulsa, Oklahoma

Two types developed... with surface active agents and either emulsifiers or dispersed solids ...overcome problems of limited penetration in highly soluble formations and fractures to increase well drainage

TWO TYPES OF RETARDED acids have been developed to overcome the problem of limited penetration provided by conventional inhibited hydrochloric acid in highly soluble formations, conventional acid spends itself rapidly in the immediate vicinity of the well bore. Surface-active agents and either emulsions or dispersed colloids (natural gums) retard the action of these new acids. Thus, retarded acids penetrate further into highly soluble formations, opening and enlarging flow channels for increased drainage into the well.

The principal effects of acidizing with inhibited hydrochloric acid are enlarging the well bore and removing plugging materials that have accumulated during drilling or during later production of well fluids. Increasing well bore size tends to provide increased fluid flow. Removing plugging materials from the face of the formation also permits increased production. A further benefit is that small channels are extended radially from the well

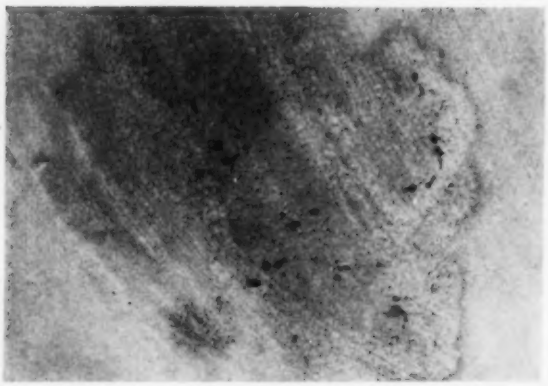

FIG. 5. **Flow channels** 1½ in. from well bore in this section of the limestone block shown in Fig. 4.

FIG. 6. **Three inches from well bore,** retarded acid had penetrated to form flow channels in limestone block of Fig. 4.

bore for short distances. However, hydrochloric acid spends so rapidly in readily acid-soluble limestone formations that such channeling action cannot extend far from the well bore.

Why retarded acids? Retarded acids were formulated to overcome this problem of limited penetration. They are designed both to clean the face of the formation and to open flow channels deep into highly soluble formations. The two types of retarded acid used employ surface-active agents and either emulsions or dispersed colloids (natural gums) to provide the desired retarding action.

Use of dispersed colloids. The retarded acid containing a dispersed colloid is basically a gelled acid having silicate control action. This gelled acid is viscous. In addition, the gum acts as a fluid loss agent. Because of its viscosity and its low fluid loss, gelled acid enters large pores much more readily than small ones, increasing their size and interconnecting them to form improved flow channels. This gelled acid also removes silicate particles within and on the face of the formation by shrinking them and keeping them at a reduced size so that they can escape with produced well fluids.

Emulsified retarded acid. The emulsified type of retarded acid is basically an acid-oil emulsion, containing special fluid loss and surface-active agents. Again, high viscosity tends to prevent the emulsified acid from entering fine pores, diverting it into larger pores. The fluid loss agent incorporated in this type of retarded acid intensifies this effect. This fluid loss material, being water-soluble, can be dissolved by the spent acid and removed from the formation upon completion of the treatment. This emulsified acid also shrinks silicate particles so that they can be removed from the formation. Following the treatment, the emulsion breaks down, both by spending of the acid and by adsorption of the emulsifying agent onto silicates.

This emulsified acid is frequently used as a fracturing fluid. Because of its viscosity, it has good sand-carrying properties. It offers a combination of fracturing and acidizing benefits, which makes it a highly effective fracturing fluid in limestone formations.

Reducing mud blocks. Both types of retarded acid have been useful in removing mud from fractures and from the face of the formation. When fractures are present, the viscosity of these acids makes them tend to enter the fractures rather than the formation pores. Often such fractures are filled with drilling mud which blocks the flow of formation fluids. Because of the surface-active chemical (an amine) incorporated in these acids, they have effectively removed such mud by shrinking the mud particles and maintaining them at a reduced size.

Action of surface-active amines. The exact mechanism by which surface-active amines reduce the amount of water adsorbed on clay surfaces and between clay platelets has not been clearly defined. However, a theory which may explain this action is based on the premise that polar imbalance exists on the surfaces of clay particles. Water molecules, which are polarized, are attracted and aligned in an oriented layer on the surfaces of clay particles and between the laminated platelets of such particles.

Each layer in turn attracts another layer of polarized water molecules. As this process continues, many layers of water may accumulate on the clay particle's surfaces, forcing platelets to separate and causing the particle to swell.

This systematic arrangement may be

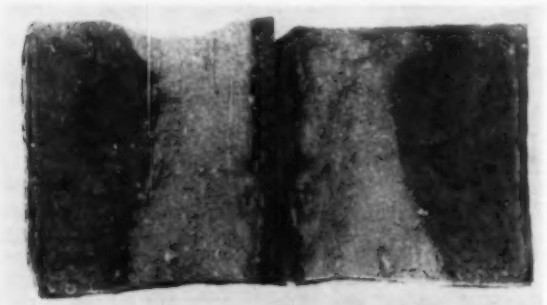

FIG. 7. **Conventional acid in fractures** does not effect much of the mud block, as this split core previously packed with mud indicates.

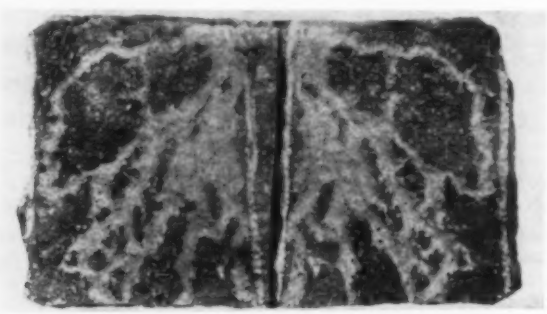

FIG. 8. **Fractured core** treated with a gelled acid type of retarded acid shows that much of the mud was removed and many flow channels formed in the fracture.

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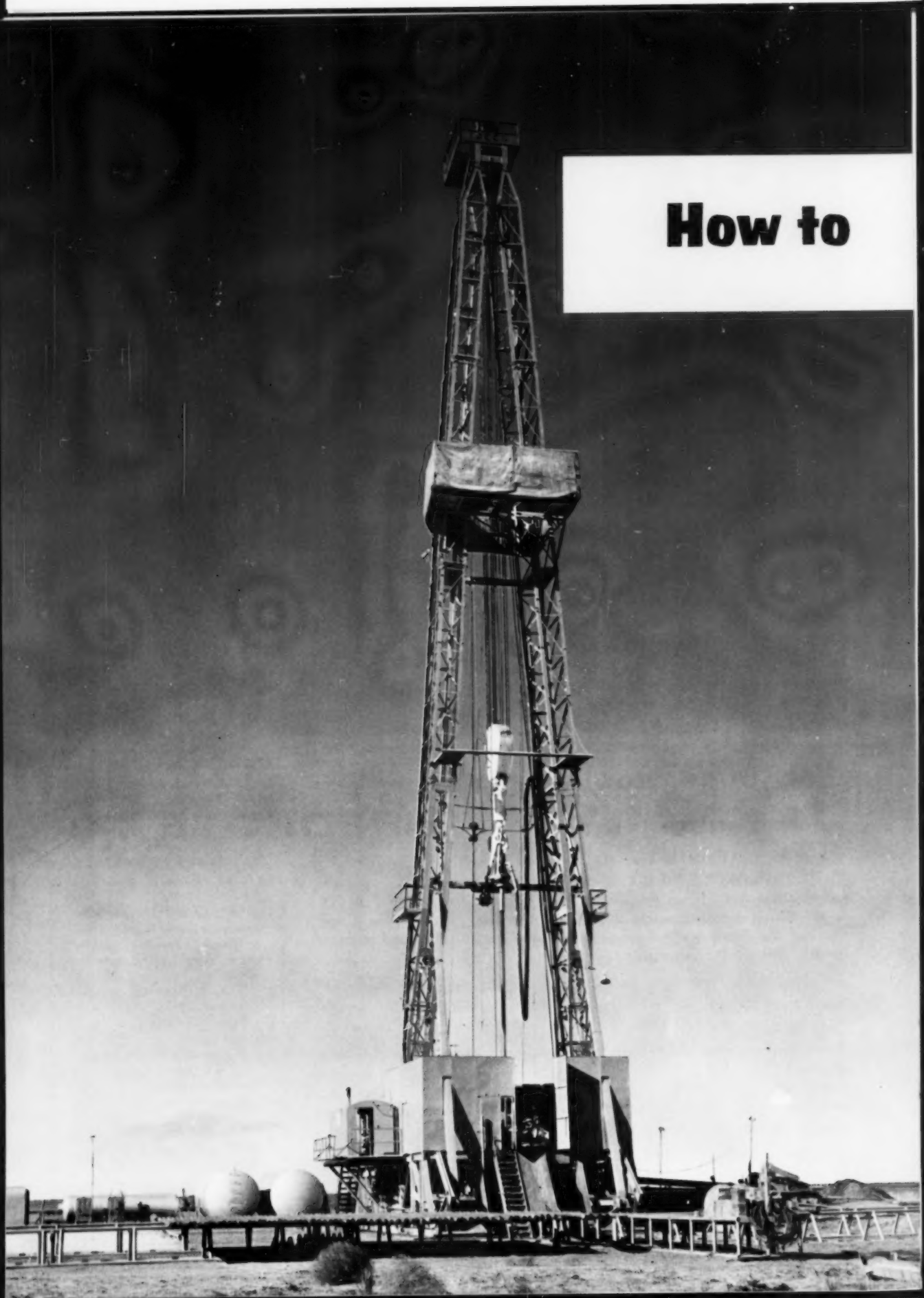

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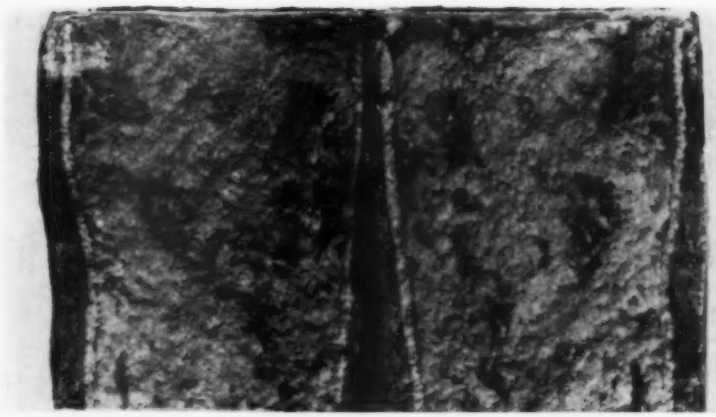

FIG. 9. **Fractured core** packed with mud, then treated with the acid-oil emulsion type of retarded acid. Much of the mud was removed, cleaning the core and facilitating fluid flow.

interrupted by the presence of ions such as hydrogen from acid. However, this reaction is reversible, and after acid shrinks clay particles, renewed particle swelling occurs when the acid spends. When an amine having a hydrophobic (water repellent) alkyl chain is present, swelling caused by polar adsorption of water molecules on the clay particles is prevented. These amine molecules have a polar end and a non-polar water repellent end. After the acid shrinks clay particles, these amine molecules displace water molecules on clay particle surfaces. The amine molecules are then attracted and held to the clay surface by the polar end of the molecule. In addition, the non-polar end repells water molecules, effectively blocking them from the surface of the clay. Thus, the clay remains shrunken after the acid acts upon it.

Acid Action Demonstrated

An interesting laboratory experiment illustrated the action of retarded acids. A simulated well bore was drilled into a limestone block, which was then treated with 1400 milliliters of 15 percent hydrochloric acid. Fig. 1 is a diagram of the shape and size of the hole formed by this acid. Fig. 2 is a photograph of a cross section of this simulated well bore following the acid treatment.

A second experiment was conducted on a similar limestone block. In this test, 200 milliliters of retarded acid was injected, followed by 1200 milliliters of 15 percent hydrochloric acid. Fig. 3 is a diagram of the channels formed by this acid treatment. Fig. 4 is a photograph of a cross section of the well bore. Fig. 5 shows a cross section 1½ in. away from the well bore, and Fig. 6 shows a cross section 3 in. from the simulated well bore.

Acid action illustrated. These illustrations show that the principal action of 15 percent hydrochloric acid was to enlarge the size of the well bore. The retarded acid, however, did not appreciably enlarge the well bore, but produced many small channels leading away from it.

The retarded acid's deepest penetration into the limestone block was about 9 in. from the well bore. Retarded acid produced nine main arteries leading away from the well bore, and each artery branched numerous times as it went further into the "formation."

Flow channels enlarged. The penetrating action illustrated by these photographs greatly increases the size and extent of flow channels through which well fluids can enter the well bore. Such retarded acids should therefore provide much better formation drainage in highly soluble formations than does conventional hydrochloric acid.

Test in fractures. Another test demonstrated that retarded acids penetrated fractures saturated with drilling mud and removed the mud more effectively than did conventional acid. Three-inch core samples were fractured lengthwise. The fracture was then propped open by thin spacers and the fracture filled with drilling mud, under 100 psi pressure. The resulting filter cake prevented fluid flow through the fracture. These core samples were then acidized, to study the relative effectiveness of various acid formulations.

Fig. 7 is a photograph of both halves of the core treated with 15 percent hydrochloric acid. Fig. 8 shows the halves of another core treated with the gelled acid type of retarded acid, while Fig. 9 shows a third core treated with the acid-oil emulsion type of retarded acid. These photographs show that conventional hydrochloric acid did not remove as much of the drilling mud as did the retarded acids.

TABLE 1. Typical Results of Retarded Acid Treatments In Oil and Gas Wells.

Well location and formation	Production		Treatment
	Before	After	
Kirby Field, Wyoming, Phosphoria Formation	9-6 bopd	100 bopd	5,000 gal acid-oil emulsion, 1 lb sand per gal
McLeod Pool, Canada, D-2 Formation	6 bopd	51 bopd	2,000 gal gelled acid and 2,000 gal crude oil
Beaver County, Oklahoma, Chester Formation	200 Mcf gas	6,160 Mcf gas	Two stages (1) 500 gal mud acid (2) 10,000 gal gelled acid
Beaver County, Oklahoma Chester Formation	1,000 Mcf gas	7,250 Mcf gas	2,000 gal 15% hydrochloric acid, followed by 5,000 gal gelled acid
Hansford County, Texas, Cleveland Lime Formation	Show gas	5,400 Mcf gas	500 gal mud acid, 10,000 gal gelled acid
Lisbon Field, Claiborne Parish, Louisiana, Smackover Lime Formation	Show oil	240 bopd	500 gal 15% hydrochloric acid, 5,000 gal gelled acid
S. W. Crescent Pool, Logan County, Oklahoma, Mississippi Lime Formation	70 Mcf gas	2,750 Mcf gas	10,000 gal gelled acid
S. W. Crescent Pool, Logan County, Oklahoma, Mississippi Lime Formation	no show	35 bopd	25,000 gal gelled acid
N. Columbian Field, Logan County, Oklahoma, Oswego Lime Formation	40 bopd	1,200 bopd	9,000 gal gelled acid
Woodward County, Oklahoma, Chester Lime Formation	3,400 Mcf gas	13,000 Mcf gas	40,000 gal gelled acid
Graham County, Kansas, Kansas City Lime Formation	48 bopd	720 bopd	1,000 gal 15% hydrochloric acid, 2,000 gal gelled acid

Field Experience

Field experience has shown that retarded acid treatments have been highly effective in increasing oil and gas production. In many cases, production following retarded acid treatments has been considerably higher than production from offset wells acidized with conventional 15 percent hydrochloric acid. Table 1 gives results of treatments of oil or gas wells in many different fields.

References

Grimm, Ralph E., "Clay Mineralogy," McGraw-Hill Book Company, 1953.

Marshall, Charles Edmund, "The Colloid Chemistry of the Silicate Minerals," Academic Press, 1949.

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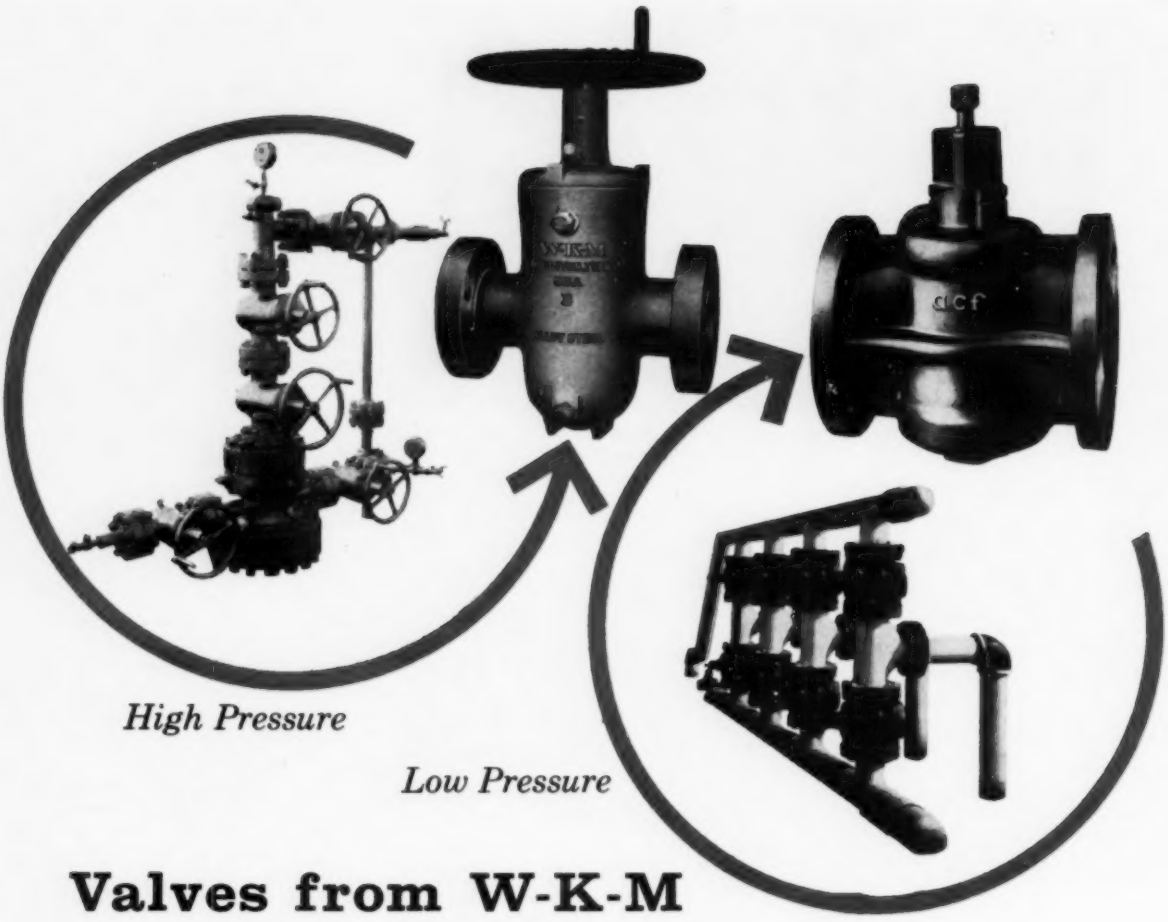

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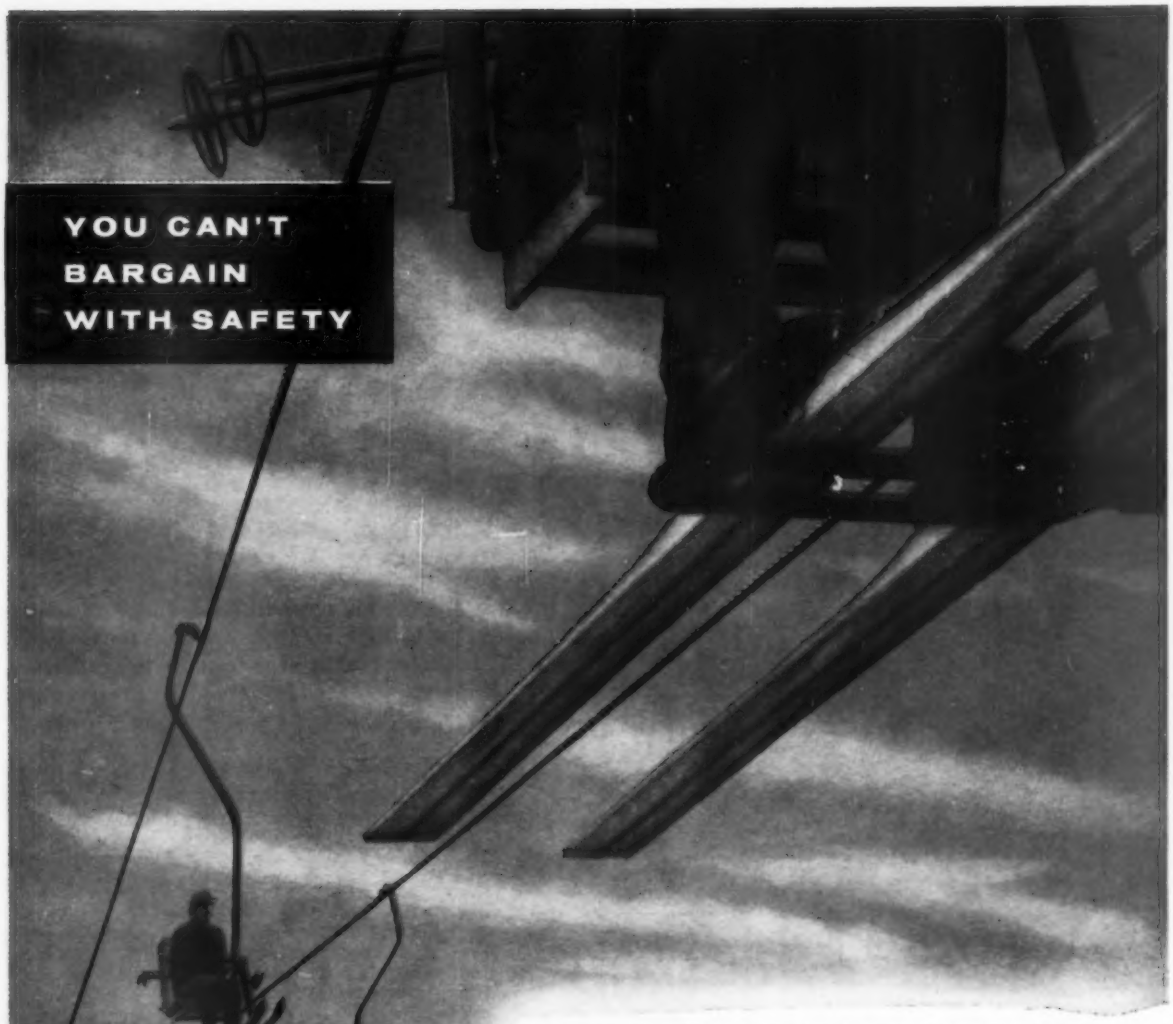

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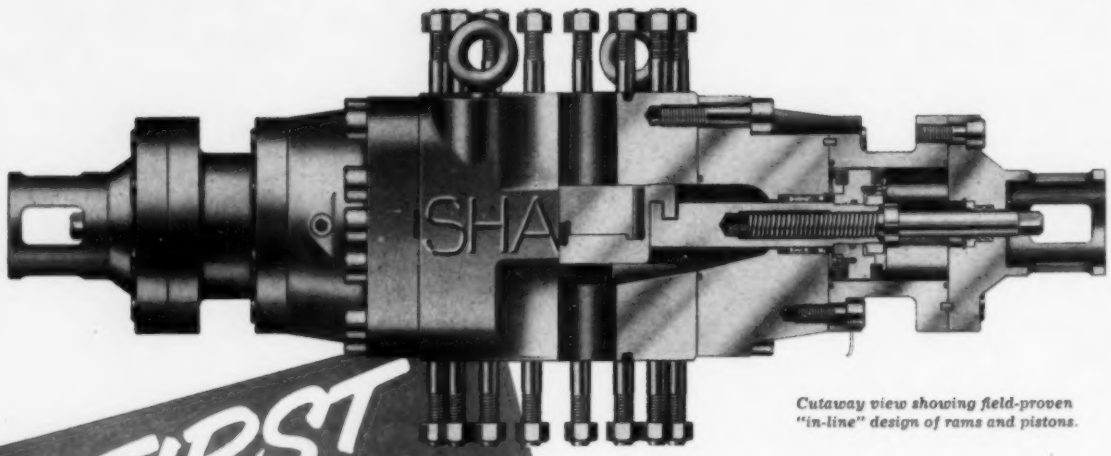

Cutaway view showing field-proven "in-line" design of rams and pistons.

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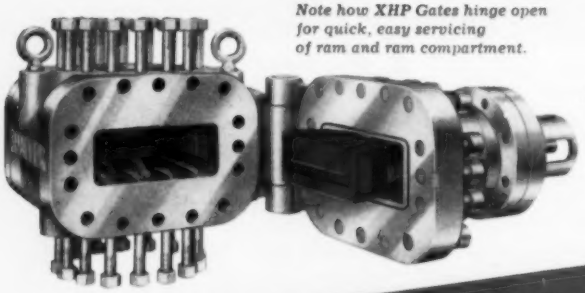
SHAFFER XHP Hydraulic Gates

Today's big news in the industry is Shaffer's new line of XHP Hydraulic Gates—the *first large bore blowout preventers in production for handling 10,000 PSI Working Pressure* (15,000 PSI Test Pressure)!*

Not only is this XHP equipment in full production (not just in test and development stages) but many units are in actual field service in various high-pressure oilfields throughout the world!

Note how XHP Gates hinge open for quick, easy servicing of ram and ram compartment.



XHP HIGHLIGHTS

XHP equipment embodies no new, untried operating principles. Its basic design features are only those operating principles that have been field-proven over years of rugged oilfield service!

XHP equipment features the same "in-line" design of rams and hydraulic cylinders that has proven so efficient on other Shaffer Hydraulic Gates. Fewer parts, simpler maintenance, greater safety!

XHP equipment incorporates an advanced *hinged body* design that greatly simplifies changing the rams as well as servicing the ram compartment.

XHP equipment can be swung open without breaking fluid lines because the fluid pressure travels through passages machined directly into the hinge pins.

* **XHP** equipment is available in 7-1/16", 9" and 11" bore sizes and all sizes are inspected and individually tested. The 7-1/16" bore size is tested to 22,500 PSI for *working* pressures to 15,000 PSI. The 9" and 11" bore sizes are tested to 15,000 PSI for *working* pressures to 10,000 PSI. All sizes can be furnished either Studded Flange or Bolted Flange type.

There are many other important features built into Shaffer XHP Hydraulic Gates. See your nearest Shaffer representative for complete details—or write direct!

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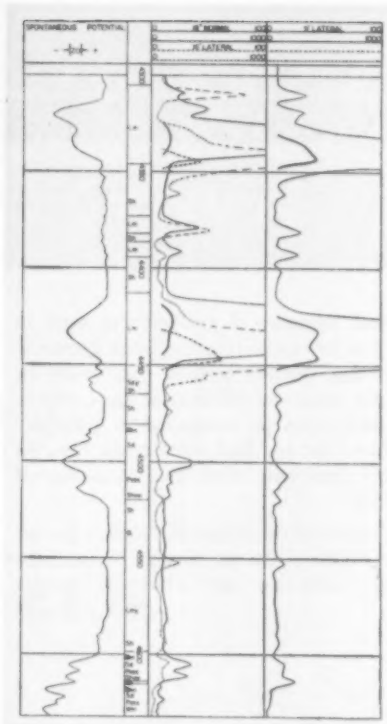
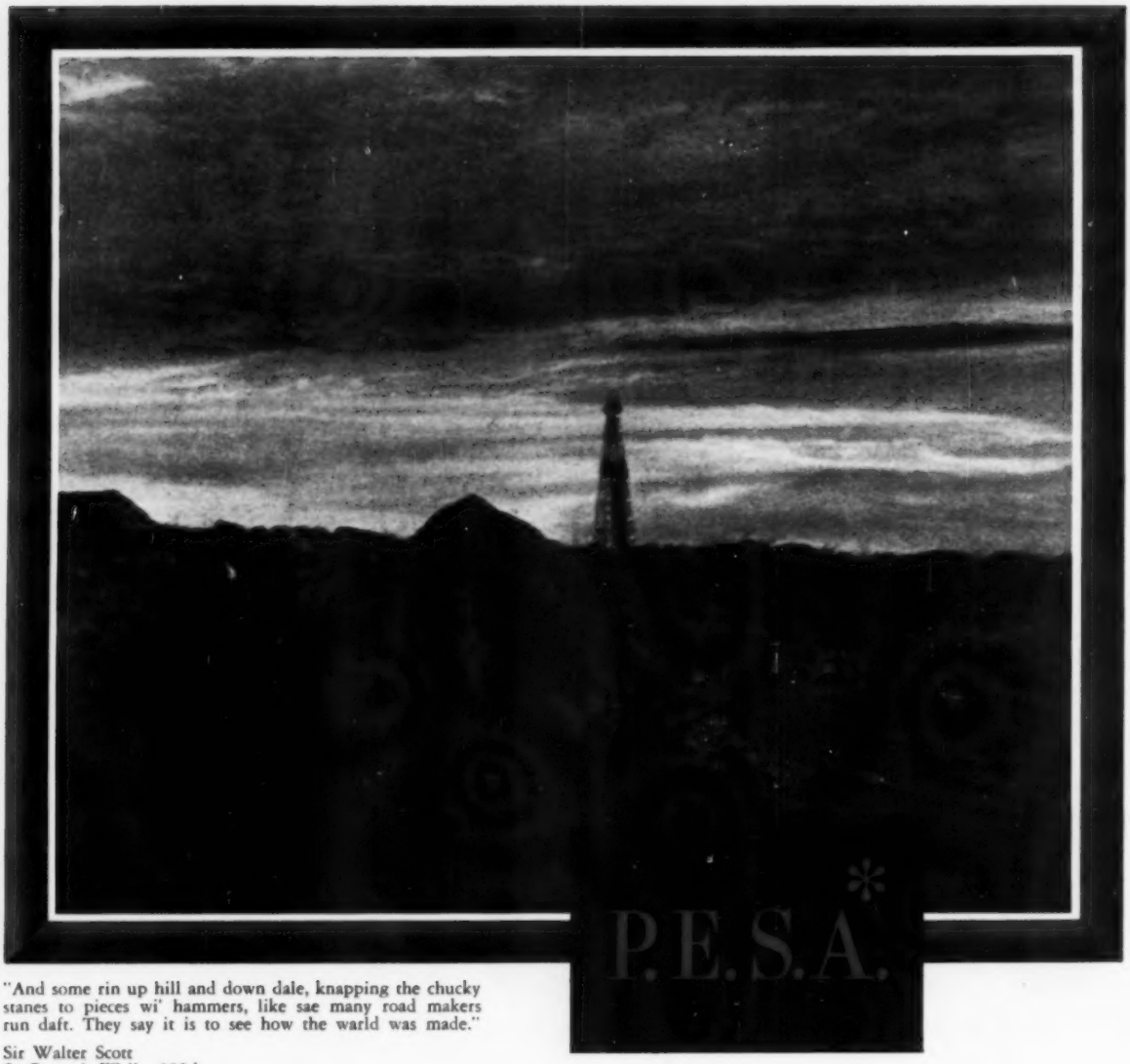


Where In The World Will They Find Oil Next?



"And some rin up hill and down dale, knapping the chucky stanes to pieces wi' hammers, like sae many road makers run daft. They say it is to see how the warld was made."

Sir Walter Scott
St. Ronan's Well—1824

We have evidence of geologists at work in 1824. It was inevitable that the "rock breakers" would one day develop sciences that would be useful in the search for oil. Present day methods, however, would not be recognized by early day proponents of the art. And much credit must be given those who spent their lives in geological interpretation.

The practice of formation and surface feature study was followed by the torsion balance, the gravimeter, refraction and reflection seismic techniques. The first geophysical prospect (torsion balance) to be proved in the United States was on the Nash Ranch in Fort Bend County, Texas. A year later, the first seismic discovery was made at Orchard, Texas.

Since that time, geophysical crews have traveled the length and breadth of the world in the search for indications of gas and oil.

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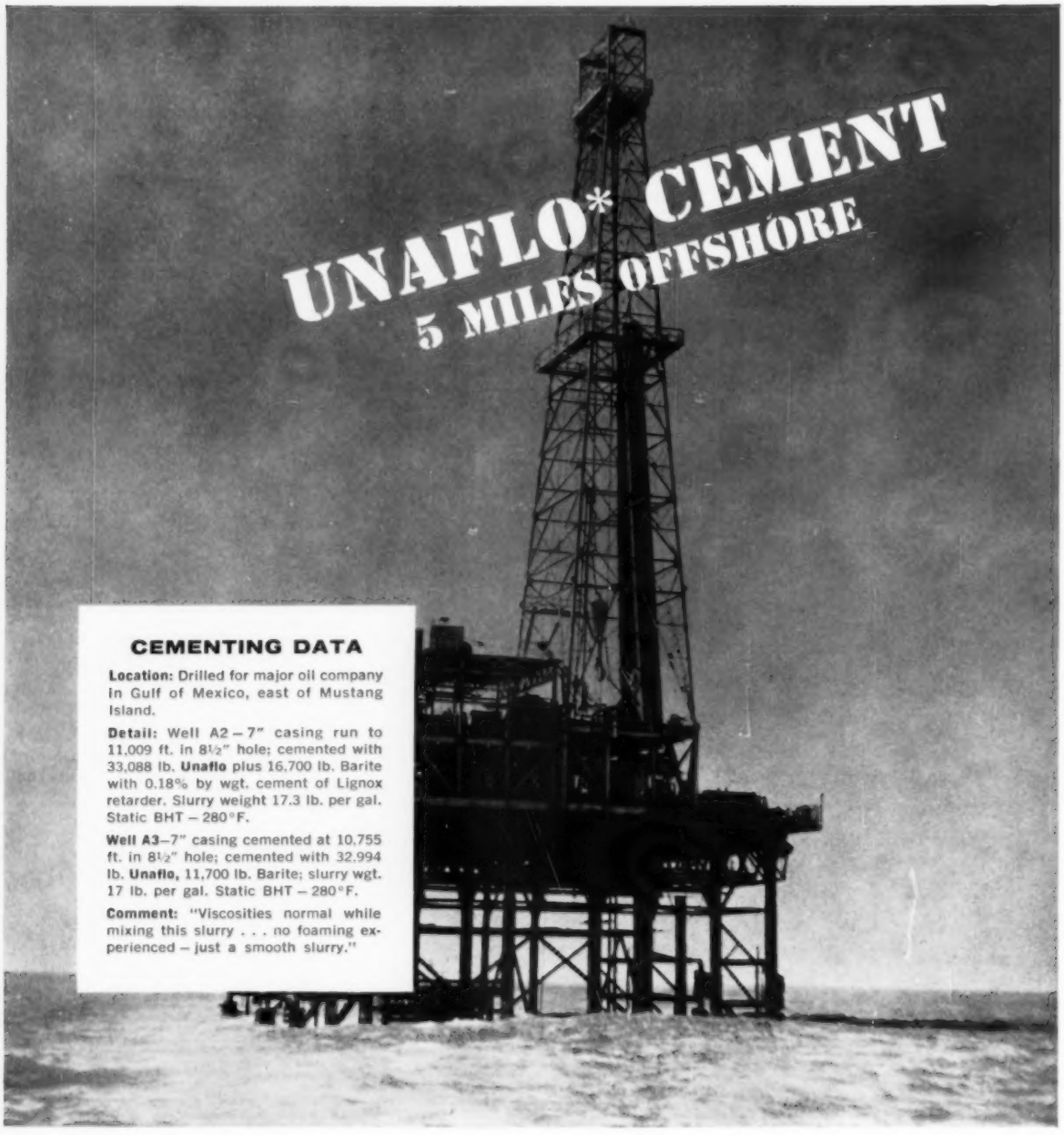

CEMENTING DATA

Location: Drilled for major oil company in Gulf of Mexico, east of Mustang Island.

Detail: Well A2 – 7" casing run to 11,009 ft. in 8½" hole; cemented with 33,088 lb. **Unaflo** plus 16,700 lb. Barite with 0.18% by wgt. cement of Lignox retarder. Slurry weight 17.3 lb. per gal. Static BHT – 280°F.

Well A3–7" casing cemented at 10,755 ft. in 8½" hole; cemented with 32,994 lb. **Unaflo,** 11,700 lb. Barite; slurry wgt. 17 lb. per gal. Static BHT – 280°F.

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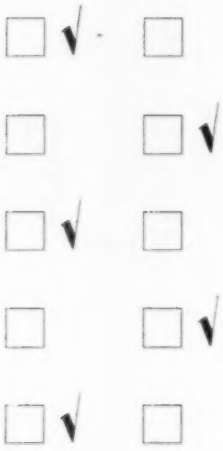

CHECKLISTS IN SAFETY INSPECTIONS

Inspections should be planned and checklists used to guide the survey of equipment and practices—here are some drilling applications

S. V. Asbury,
Accident Prevention Representative, Gulf Oil Corporation, Harvey, Louisiana

WHEN MAKING A VISUAL INSPECTION a man too often looks and sees the most obvious points of interest, while other points of equal importance go unnoticed. This natural reaction takes place when an "on the job" inspection is made. When inspecting a drilling rig, the safety engineer may observe an acetylene hose scattered on the derrick floor and call this hazard to the driller's attention.

Yet, he will fail to notice whether the dead line of the traveling block was anchored properly. This inspector saw the most prominent hazard on the job scene, but because his inspection was casual and not scientifically planned, many other important hazards were not noticed.

An individual making an inspection must use a checklist previously designed for the task.

To illustrate this point further, let's look at a blowout preventer hookup on a barge type drilling rig located in South Louisiana. A safety inspection of this location was made to determine hazards on this job scene.

Presented under the title: "The Use of Checklists in Safety Inspections," at the 45th National Safety Congress, October 21-25, 1957, Chicago, Illinois, and sponsored by the National Safety Council.

After viewing this work area the most obvious hazards were:

- The coating of drilling mud on the blowout preventers.
- The height at which employees must work without proper scaffolding.
- Poor housekeeping.

There are additional points, though not as obvious, but equally important. For example:

- Are rams in good condition?
- Do blowout preventers operate properly?
- Do blowout preventer connections meet company specifications?
- Do drilling crews know how to operate blowout preventers?
- Are closing wheels installed a proper distance from blowout preventers?

Specifically and scientifically designed checklists can guide the inspector. Casual inspections without a checklist, with the findings mentally recorded are a poor excuse for the real thing. Many accidents, some fatal, could have been prevented had a planned checklist inspection been made and action taken as a result of these findings.

Determining the Need

Whenever specific information is needed—information best obtained by personal observations such as the condition of field equipment—the inspection should be systematically planned and a checklist developed afterward.

Some inspections are conducted to cite a specific problem, for example, the condition of working surfaces that have caused numerous accidents. Other inspections are general, planned to detect unsafe acts and conditions. In any case, the reason for the inspection should be firmly fixed, the manner it will be conducted decided upon, and serious thinking done before the inspection begins. After this, developing a checklist is a natural followup to make the inspection complete.

The possibilities for using inspection checklists are unlimited. They are used for simple inspections, such as determining the condition of first aid kits and for more complex inspections of checking an offshore drilling platform for both unsafe practices and unsafe conditions.

Selling a Checklist Project

Management refers to supervisory personnel, from the top level of the president to the lower level of the roustabout foreman. Line management refers to supervisors of the operating departments, and operating personnel refers to all employees in the line organization.

When the need arises for a checklist, the safety engineer must decide which phase of management should develop the needed checklist. The safety engineer should act only in an advisory capacity to management, lend-

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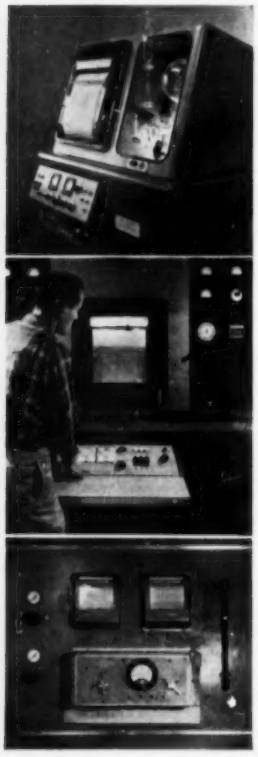

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ing guidance and assistance. Only in rare cases should the safety engineer develop and use the safety checklist solely on his own.

To decide what level of management should develop the checklist depends on its purpose. A checklist for inspecting a field for a local safety meeting report, should be developed by the field foreman. The specific selling tactics would take the same course as any other recommendations made by the safety engineer.

If the problem is more extensive, for example, if a number of drilling rigs are involved or the problem covers many phases of a company's operation, it might be necessary to make a recommendation to the top level supervisor of the concerned department. A simple rule is to do the selling job at the lowest level of supervision that has the authority to take action.

Using the Checklist

The checklist should not only be developed by operating people, but it can be most effectively used by operating people. **The safety record of a company is not the responsibility of the safety department, but a responsibility of management.** By the same token, safety inspections should be made by qualified operating people, assisted by the safety engineer. It is sheer folly if the safety engineer thinks he is an expert in every phase of the operations.

No safety engineer has a first-hand working knowledge of pilot and temperature controls of gas regulators, weight lever valves on separators, Christmas tree valves, heater treaters, pop-over regulators, or many of the other complex pieces of equipment operating in the oil patch. A safety inspection should be a cooperative effort with the safety engineer assuming his rightful position of advisor. When he oversteps these bounds, then he is assuming responsibilities delegated to operating personnel.

To illustrate how a checklist can be either a useful accident prevention tool, or a crutch, let's review the personal experience of "John Doe," safety engineer.

Doe used to inspect drilling rigs by observing the most obvious hazards. Had he been asked about the rams or turnbuckles on the blowout preventers, he could not have reported their condition there.

Realizing that little could be gained by this method, Doe gave birth to his first checklist. It helped, but at the same time it created resentment among the field people and soon died. Causes of death were:

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- Management was not shown the need for such inspections.
- Management was not shown the need of a checklist for making these inspections.
- Line management should have made the inspections with the assistance of the safety engineer.

Doe's initial checklist inspections were not completely successful. But now he has a drilling rig checklist based on his original brainchild that his company is using successfully. Why did the company's checklist work? Simply because the safety department only originated the idea and rendered advice. The actual development work was done by the line organization. The checklist inspection is actually made by qualified operating personnel. Doe's checklist failed because he assumed responsibilities which rightfully belonged to line management.

Here's how a checklist works in actual practice. Assume that the Spindletop Oil Company contracts all its drilling. Company employees such as toolpushers, engineers, and field foremen perform supervisory duties on this rig. The company is concerned with accidents that might injure these employees or delay production. Therefore, it is the company's policy to inspect all contract rigs to insure that equipment and practices meet Spindletop's requirements.

At irregular intervals the company drilling engineer or drilling supervisor inspects the rig. Inspections are made at irregular intervals because a truer picture is obtained than if the crews are anticipating the inspection. Another reason for irregular inspections is that it is virtually impossible to make an inspection such as this when running a string of casing or when a well is kicking.

In any event, the inspection is made by the company drilling engineer and usually with a representative of the contractor.

After the inspection, the findings are discussed with the contract toolpusher, and corrections and changes within authority of the toolpusher are agreed upon. If changes recommended are beyond his authority, the top level drilling supervisor of the company must discuss the matter with the top level supervisor of the contractor.

This plan of action works smoothly. The contractor benefits as much from the inspector as the operator. On these inspections the Spindletop safety engineer occasionally accompanies the company drilling engineer and renders advice as needed.

The reason this plan works successfully can be illustrated by the comment of the drilling engineer, when asked his opinion of the checklist: "We think that the mechanics are fine and the checklist plan works good. After all, we helped develop it."

If "on the job" inspections are to be successful, the safety department should plan the plays, but the line organization should lead the interference, and carry the ball. If this is done, all concerned should achieve their goal of valuable safety inspections. This in turn will lead to safer working conditions, safer working practices and, without a doubt, fewer accidents and injuries. ★ ★ ★

LAUGH WITH BARNEY

A woman advertised a 1957 Cadillac for $50. A man answered the ad and the first thing he asked was, "What's wrong with the car?" She said, "Nothing. If you want it for $50, give me the $50 and take it away. If you don't want it, please don't waste my time."

He asked for the keys and went to the garage and backed the car out, parked it in front of the house, counted out $50, and handed it to the owner. Then he commented: "Now you have your $50. What's the catch?" She replied: "My husband just died and in his will he instructed that the Cadillac be sold and the proceeds be given to his secretary."

Vibroseis:

Experimental Seismic Method Uses Mechanical Vibrator

A new seismic method called Vibroseis, for use by geophysical crews exploring for oil, employing a mechanical earth vibrator and a giant electronic computer, is being developed by Continental Oil Company.

John M. Crawford, director of exploration research, and William E. N. Doty, supervising research geophysicist, both of Continental and co-inventors of the method, say that the system is "difficult and expensive and still in the experimental stages."

Both the vibrator and the computer were designed and built in Conoco's research laboratories at Ponca City.

"It is hoped the new method will eventually replace or supplement the conventional dynamiting method now used in seismic work," said Crawford, "but our problems are not all solved."

The mechanical earth vibrator used in the new method is only 18-in. long and is mounted on a steel-wheeled trailer attached to a tow truck. For transporting between locations, the trailer can be loaded on the bed of the truck. The vibrator is powered by an electric motor. Counter-rotating weights within the small vibrator box pound the earth, exerting a force up to 14,000 lb when the frequency is 60 cycles per second.

Sound waves or signals travel down through the earth's strata and are reflected to the surface where they are recorded on magnetic tape. The tape is then sent to the giant computer in Conoco's research laboratories at Ponca City, where, after processing, it emerges as a "Vibrogram" chart for scientific study.

"In addition to dynamiting, the new method would eliminate the need to drill 50 to 500-ft holes for explosives, always a nuisance to property owners," Crawford added. "Among the many difficulties facing our researchers is the fact that the signal from the vibrator is inherently weaker than the signal from the explosives and is, therefore, difficult to detect in the presence of wind noise, useless surface waves and other vibrations."

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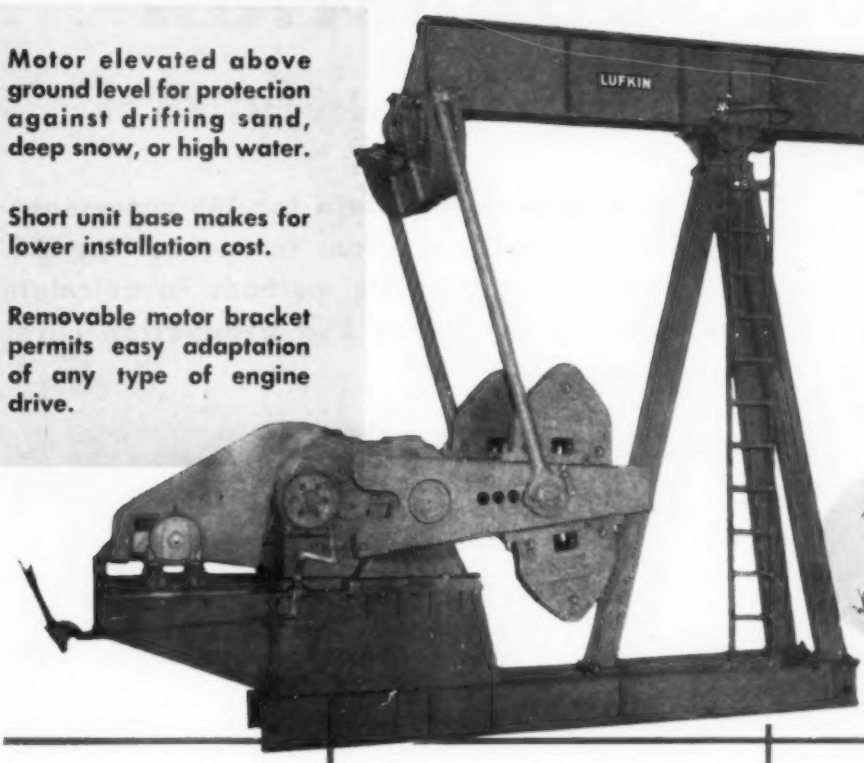

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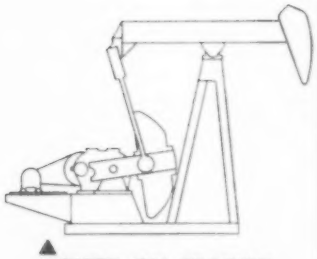
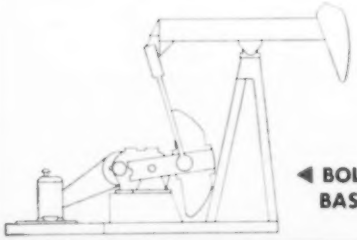
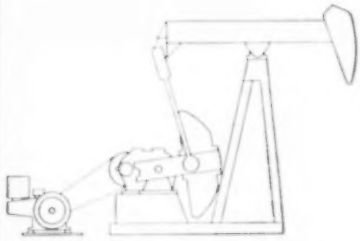


▲ BOLTED ON BRACKET FOR ELECTRIC MOTOR



◀ BOLTED EXTENSION BASE FOR GAS ENGINES



▲ STUB BASE WITH ENGINE SET SEPARATELY

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THE PLUNGER LIFT METHOD OF OIL PRODUCTION

New field performance data for 145 representative wells or well conditions throughout the U.S. are presented along with methods to calculate gas volumes, pressures and production rates

Carrol M. Beeson,
Petroleum Engineering Department, The University of Southern California, Los Angeles, California
and
Donald G. Knox and John H. Stoddard,
The National Supply Company, Los Angeles, California

PART 1 PRINCIPLES OF OPERATION AND LEAST SQUARES EQUATIONS

USE OF THE FREE PISTON METHOD of artificial lift in oil and gas wells is increasing at a rapid rate. Several of the reasons for this increase stem from general developments in the industry. That is, wells are being drilled deeper, pressure maintenance is on the increase, and more data are being obtained on bottom-hole conditions and productive capacities.

The first of these developments makes artificial lift more difficult and the second increases the amount of gas available for lift purposes. Additional bottom-hole data have helped derive accurate methods for predicting performance of the free piston system.

Supplementing these general developments, equipment for this system continually has been improved. In addition, new designs for the equipment have produced various types of plungers for use in a wide variety of oil and gas wells.

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How the Free Piston System Works

One of the most efficient methods of producing oil involves the use of the cycle controlled, expanding plunger. The expanding segments make continuous contact with the walls of regular API tubing strings, thereby forming an effective seal between the lifting gas and the lifted liquid. On reaching the surface, a valve in the plunger is opened mechanically, permitting the plunger to fall through the gas and oil to the footpiece spring.

On reaching the footpiece, the valve is closed mechanically, so that gas under pressure may lift the plunger to the surface with another load of oil. The plunger starts upward when the motor valve in the flow line is opened by the cycle controller, usually after the pressure in the casing has reached some predetermined value. The motor valve in the flow line ordinarily is closed by the arrival of the plunger at the surface.

Editor's Note: Although the free piston method of production is not new, equipment has been improved in recent years, and volumes of performance data have been collected throughout many producing areas. A more thorough study of the engineering factors effecting this method of artificial lift has made it possible to better design installations for greater lifting efficiencies. This series contains these latest findings and are presented here to further the understanding of the free piston system as well as to provide up-to-date engineering data for more efficient operations.

This is the first of five parts on the subject. Others to follow will be:

Part 2: **Constructing Nomographs to Simpify Calculations**

Part 3: **How to Use Nomographs to Estimate Performance**

Part 4: **Examples Demonstrate Use of Nomographs**

Part 5: **Well Selection and Applications**

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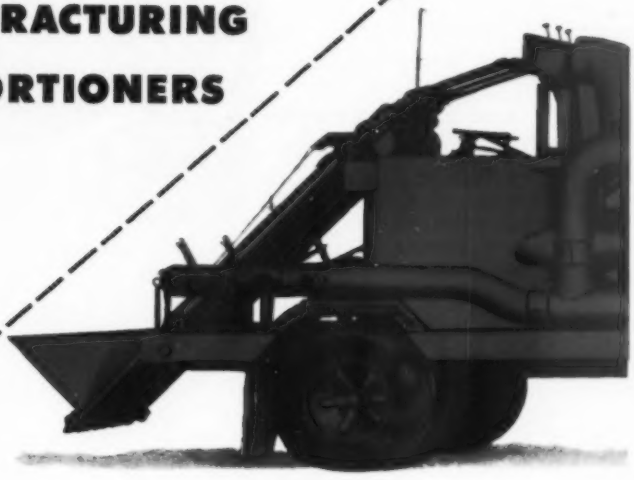

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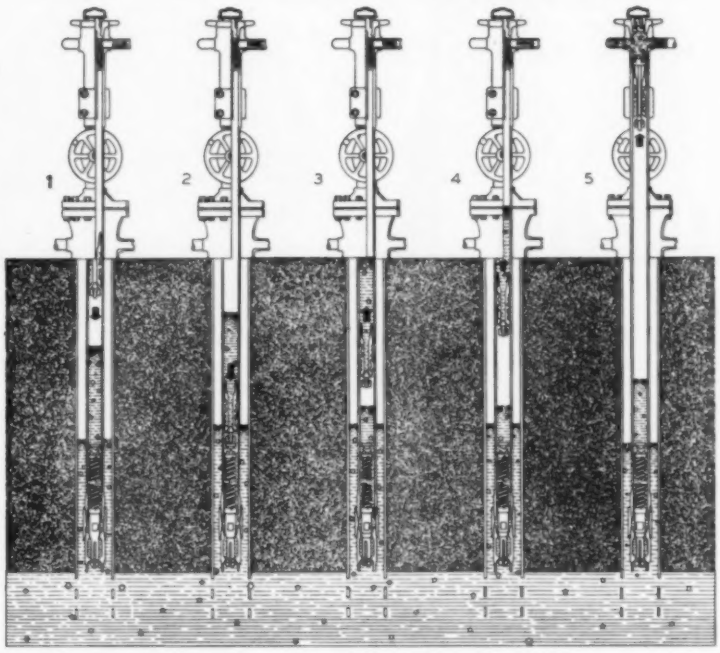

HOW THE FREE PISTON SYSTEM WORKS

1. Well closed, plunger falls by gravity. Casing pressure low, and starts increasing.
2. Upon striking footpiece, plunger valve closes. Casing pressure still increasing.
3. Casing pressure peaks, plunger starts lifting oil column, tubing pressure drops.
4. Well opened, casing pressure drops, tubing pressure drops, then rises as fluid reaches surface.
5. Well closed, plunger strikes bumper, valve opens and it is ready to fall again. Casing pressure is low, completing cycle.

The flow line is opened and closed to gain the advantage of controlled intermittent flow. Combined with this advantage is the piston-like efficiency of the expanding plunger.

Use of make-up gas. Some wells do not produce sufficient formation gas to operate the plunger, so use is made of circulated gas. In that case, a convenient source of supply is connected to the casing, and gas is injected continuously at a rate sufficient to supplement the produced formation gas.

Controlling the cycle. Ordinarily, casing pressure is used for controlling the cycles and no tubing packer is set. It is this standard type of installation which is the primary subject of the present study. Cycles may be controlled, however, by tubing pressure or by time, wherever casing-pressure control is impracticable. Time control is especially appropriate for removing accumulations of water or condensate from gas wells. This method also is used to prevent overloading gas-gathering systems, by ensuring that each well in a group starts flowing at a different time.

The early plungers, not being controlled by an instrument, were allowed to "free cycle" while the flow line was open continuously. This method is still employed in some cases, but the equations obtained from the present investigation do not apply to this type of operation.

The cycle controlled plunger is so flexible that it may be used under a wide variety of operating conditions in a given well. It was desirable, therefore, to develop a quantitative method of predicting the requirements and performance for various sets of operating conditions. This would make it possible to establish the most suitable conditions for any given well. Then, the predicted requirements and performance could be compared with those for other methods of production.

Field data aid analysis. In order to put the free piston system on a quantitative basis, field data were collected from many producing areas of the U. S. and analyzed to determine the variables which control gas and pressure requirements.

FREE PISTON PERFORMANCE

Early Predicting Methods

For several years while the early stages in equipment development took place, there was no reliable method of predicting performance of the free piston system. There were some charts which related operating pressure and production rate for various depths. There was also a means of predicting effectiveness, that is, the ratio of the expected rate of production to the rate computed for a zero flowing bottom-hole pressure.

These methods were based on data obtained with the old free cycling plunger. They soon proved inadequate for the better sealing and controlled plunger. Very little study had been made of gas requirements. Available charts on requirements of gas volume were unreliable, so rules of thumb were often used in their place.

Data for Cycle Controlled Expanding Plunger

By 1954, it had become apparent that the older charts should be replaced by prediction methods based on data obtained with the cycle controlled, expanding plunger. Accordingly, an intensive effort was made to obtain field data on this type of equipment that would be representative of operations throughout the oil producing areas of the U. S. and covering wide ranges of operating conditions. These data are presented in Tables 1 and 2.

All data received from operators have been included in these tables, except where inconsistencies were apparent. Of the 70 wells (or well conditions) with 2-in. plungers, 43 were from the Mid-Continent, 14 from California and 13 from the East.

Of the 75 wells (or well conditions) with 2½-in. plungers, 61 were from California, 12 from the Rocky Mountains and 2 from the Mid-Continent. Distribution of the other variables involved in well data also were quite suitable, as shown in Table 3.

The authors sincerely appreciate the fact that this excellent distribution is due to many engineers and operators who so generously collected and submitted the data.

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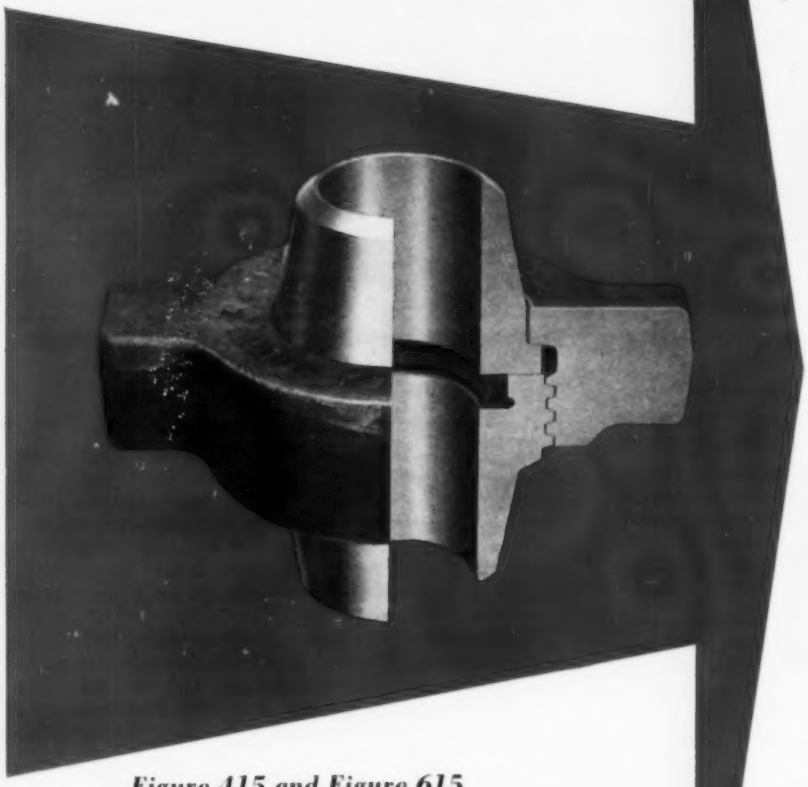

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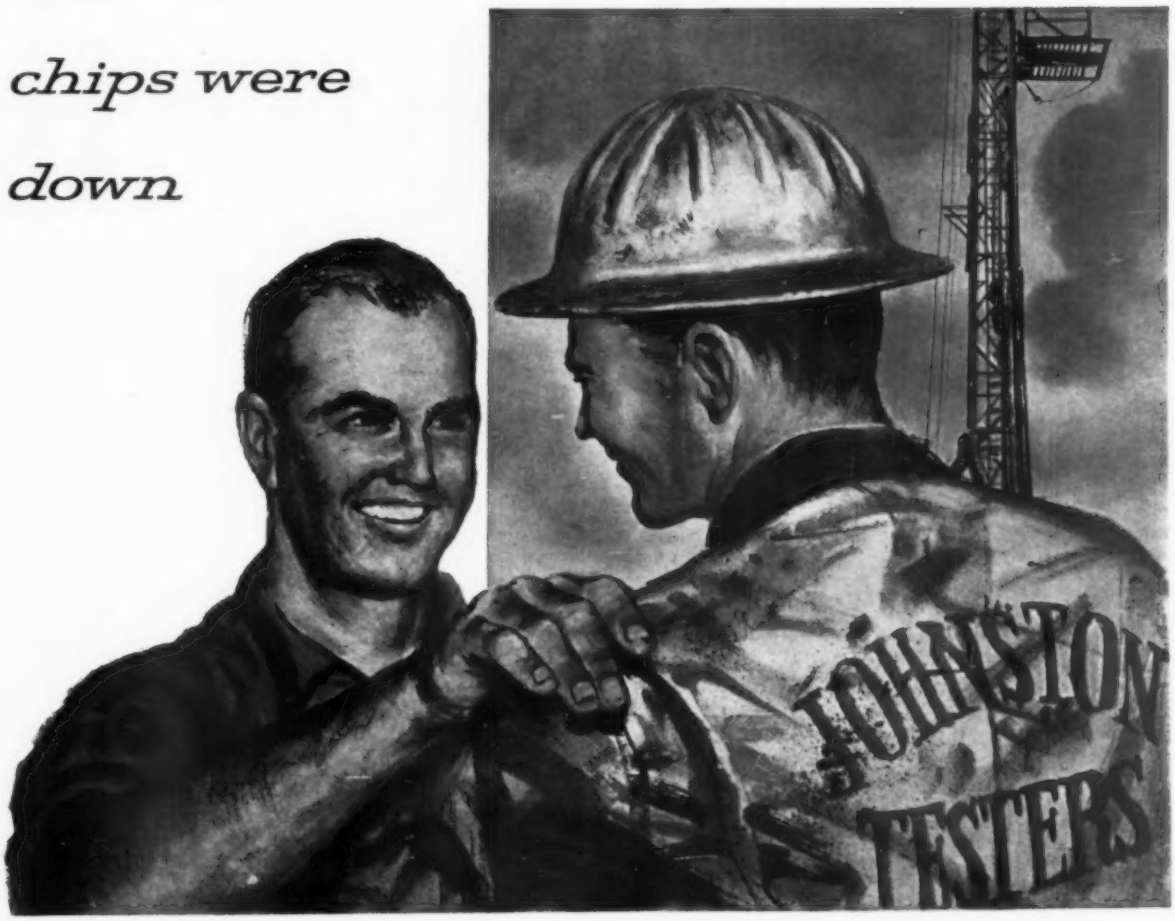

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TABLE 1. Well Data for 2-in. Plungers.

Well	Period Averaged Days	Gross Liquid B/D	Net Oil B/D	Circulated Gas Mcf/D	Gross Gas Mcf/D	Casing Pressures psig Max.	Casing Pressures psig Min.	Tubing Pressures psig Max.	Tubing Pressures psig Min.	Trap Press. psig	Cycles per Day	Oil Gravity °API	Casing Gas Gravity Referred to Air	Choke or Bean Setting inches	Tubing & Casing Sizes to Footpiece Inches, OD Tbg	Tubing & Casing Sizes to Footpiece Inches, OD Csg	Plunger Footpiece Depth Ft	Tubing Depth Ft
1	—	20	20	0	108	620	550	550	490	25	35	44	—	32/64	2⅜	5½	7673	7720
2	—	—	4	0	50	380	290	—	20	20	10	42	—	48/64	2⅜	7	7002	7017
3	—	—	10	0	50	225	200	—	36	36	80	40	0.72	48/64	2⅜	5½	7855	7870
4	—	—	12	0	50	280	220	—	30	30	9	40	—	32/64	2⅜	5½	7713	7728
5	—	—	14	0	150	360	310	—	20	20	24	40	—	32/64	2⅜	5½	7852	7867
6	—	—	15	0	150	370	310	—	20	20	18	40	—	40/64	2⅜	5½	7830	7860
7	—	13.8	13.8	0	138.2	290	250	240	120	20	28	41	—	24/64	2⅜	5½	7715	7770
8**	—	12.4	12.4	0	144.4	340	300	340	150	20	23	41	—	24/64	2⅜	5½	7715	7770
9	1	17	9	65	81	470	415	280	160	60	18	50.0	0.775	30/64	2⅜	5½	8946	9084
10**	1	14	4	67	74	440	410	350	150	60	12	50.0	0.775	30/64	2⅜	5½	8946	9084
11**	1	15	2	77	81	575	520	400	90	60	14	50.0	0.775	30/64	2⅜	5½	8946	9084
12**	1	11	3	61	66	575	520	400	90	60	14	50.0	0.775	30/64	2⅜	5½	8946	9084
13	1	9	3	158	163	365	325	340	120	10	16	50.0	0.775	30/64	2⅜	5½	9114	9157
14**	1	7	2	124	128	365	325	340	120	65	16	50.0	0.775	30/64	2⅜	5½	9114	9157
15**	1	8	4	84	91	455	410	350	85	70	16	50.0	0.775	30/64	2⅜	5½	9114	9157
16**	1	9	5	70	79	425	380	300	100	70	16	50.0	0.775	30/64	2⅜	5½	9114	9157
17**	1	6	3	67	72	400	350	320	90	70	16	50.0	0.775	30/64	2⅜	5½	9114	9157
18**	1	9	4	67	74	420	380	350	90	70	18	50.0	0.775	30/64	2⅜	5½	9114	9157
19	30	21	13	40.0	53.4	200	180	140*	30*	30	40	36.9	0.78	Open	2⅜	5½	4600	4612
20	30	11	6.7	33.0	43.7	180	160	110	30*	30	37	36.9	0.78	Open	2⅜	5½	4621	4625
21	31	18	11	37.0	48.0	210	180	140	30	28	43	36.9	0.78	Open	2⅜	5½	3808	3883
22	30	9.5	8.2	0	33.7	400	360	340*	200	30	21	33.3	0.78	3/8	2⅜	5½	7711	7718
23	28	35	35	0	187.4	500	440	440*	125	125	35	37.0	0.78	1/2	2⅜	5½	6630	6664
24	—	17.6	17.6	0	48.2	425	410	390	15	10	18	40	—	40/64	2⅜	9⅝	6400	6455
25	6	63.2	51.0	0	500.2	372	362	352	90	85	67.5	37.7	0.732	19/32	2⅜	7	11501	11506
26**	4	61.1	47.3	0	470.7	390	378	320	100	85	71.5	37.5	0.728	19/32	2⅜	7	11501	11506
27	1	16.0	4.8	282.1	435.4	310	280	250	70	85	47	26.5	0.633	64/64	2⅜	7	11665	11670
28	61	27	26	88	276	195	185	145	81	81	84	35.6	0.789	32/64*	2⅜	7	6094	6511
29	30	25	21	0	193	190	180	100	60	60	96	36	0.70	3/8	2⅜	11¾,7	5959	5965
30**	30	24	20	0	221	165	160	130	60	60	72*	36	0.70	3/8	2⅜	11¾,7	5959	5965
31**	31	22	18	0	202	175	170	140	60	60	72*	36	0.70	3/8	2⅜	11¾,7	5959	5965
32**	30	21	18	0	152	175	170	140	60	60	72*	36	0.70	3/8	2⅜	11¾,7	5959	5965
33**	31	19	16	0	116	175	170	140	60	60	72*	36	0.70	3/8	2⅜	11¾,7	5959	5965
34	1	6.3	4.6	0	90.0	203	190	170	21	—	45	38	—	1/2	2⅜	7	7243	—
35	1	5.1	1.7	0	62.6	180	168	170	7	—	46	37	—	1/2	2⅜	7	6972	6990
36	1	7.2	5.9	0	52.9	180	168	170	18	—	28	37	—	29/64	2⅜	7	6946	—
37	1	16.7	16.7	0	110	120	110	100	18	—	86	36	—	—	2⅜	7	6984	7026
38	1	13.8	11.3	0	34.8	180	168	170	18	—	37	37	—	34/64	2⅜	7	6947	6957
39	1	7.6	7.1	0	91.4	250	225	230	23	—	24	35	—	1/2	2⅜	7	7102	7132
40	1	5.3	5.0	0	57.5	270	250	250	20	—	26	35	—	—	2⅜	7	6850	—
41	1	4.8	4.8	0	66.0	125	115	115	16	—	44	36	—	1/2	2⅜	7	7092	—
42	1	6.9	6.5	0	52.4	265	250	250	20	—	30	35	—	—	2⅜	7	7101	—
43	1	6.9	6.9	0	38.8	283	260	260	20	—	17	35	—	—	2⅜	7	6969	—
44	1	15.8	15.6	0	88.5	268	258	250	24	—	33	36	—	—	2⅜	7	6951	6966
45	1	4.7	3.5	0	44.0	115	105	105	16	—	35	36	—	1/2	2⅜	7	7087	7102
46	1	5.5	5.5	0	52.6	248	225	230	20	—	25	35	—	—	2⅜	7	7213	7229
47	1	6.2	6.2	0	184	205	175	180	24	—	27	35	—	—	2⅜	7	7242	7254
48	1	16.1	16.1	0	70.0	510	480	480	24	—	12	37	—	32/64	2⅜	7	7065	—
49	1	49.8	49.8	0	187	330	310	310	22	—	56	36	—	—	2⅜	7	6863	6897
50	1	38.6	34.8	0	82.5	480	—	320	0	0	36	—	—	—	2⅜	7	—	6995
51	31	—	11.07	0	165.2	195	165	200	160	30	26	42	0.8	1/2	2⅜	5½	7531	7563
52	31	—	13.83	0	87.5	495	430	400	130	30	10	42	0.8	1/2	2⅜	5½	7514	7576
53	1	14	14	0	109	680	630	520	70	20	28	45	—	23/64	2⅜	5½	4755	4760
54	1	10.4	8.4	0	28.4	650	605	540	50	20	9	46	—	30/64	2⅜	5½	5020	5020
55	1	40	38	0	42	720	680	650	30	20	14	—	—	32/64	2⅜	5½	4785	4820
56	1	4.2	4	0	8	300	260	250	200	15	4	41	—	20/64	2⅜	5½	4140	4144
57	1	11	10.5	0	23	350	310	260	150	20	6	42	—	18/64	2⅜	5½	3840	3844
58	1	18	17.5	0	30.1	600	550	500	375	20	7	41	—	30/64	2⅜	5½	4150	4154
59	1	42	42	0	500	820	800	700	580	550	103	44	—	34/64	2⅜	5½	4422	4430
60	1	40	40	0	80	360	340	250	40	40	29	41	—	32/64	2⅜	5½	4185	4185
61	1	14	14	0	32.3	740	700	520	70	40	16	42	—	30/64	2⅜	5½	5172	5187
62	1	26.8	26.8	0	72.9	690	630	500	100	50	12	42	—	28/64	2⅜	5½	5180	5210
63	1	16	14	0	35.2	670	635	500	70	20	7	42	—	17/64	2⅜	5½	5190	5194
64	30	45	45	0	50*	180	160	125	50	40	96	46	—	8/16	2⅜	4½	3240	3262
65	30	9	8	0	14*	160	140	160	115	12	48	46	—	8/16	2⅜	5½	3180	3220
66	1	15.2	15.2	0	25	195	175	—	—	70	42	—	—	1/2	2⅜	5½	3100	3150
67	1	12	12	0	75	85	75	—	—	25	72	—	—	5/16	2⅜	5½	3000	3050
68	61	43	43	0	32	400	350	350	155	75	32	38–40	—	1/2	2⅜	5½	3439	3439
69	31	30	30	0	35	400	370	290	110	75	20	38–40	—	1/2	2⅜	5½	3534	3534
70	31	10	10	0	170	315	250	290	175	40	36	38–40	—	3/8	2⅜	5½	4140	4140

TABLE 2. Well Data for 2½-in. Plungers.

1	31	26	25.5	142	153	183	168	150	50*	35*	104	37.5	0.738	3/4	2⅞	7	3756	3768
2	9	44	17	178	178	245	200	150	50*	35*	125	37.5	0.738	3/8–1/2	2⅞	5½	3633	3638
3	11	70	49	150	190	205	175	150	50*	35*	110	37	0.720	3/8–1/2	2⅞	5½	3606	3614
4	7	31	28	248*	258	185	155	150	50*	35*	120	37.5	0.738	3/8–1/2	2⅞	5½	3629	3637
5	20	88	74	125	140	190	166	150	50*	35*	115	37.5	0.720	3/8–1/2	2⅞	5½	3634	3640
6	13	108	101	133	143*	200	172	150	50*	35*	120*	37	0.720	3/8–1/2	2⅞	7	3793	3799
7	18	42	23	234	234	235	215	150	50*	35*	120*	36.5	0.745	3/8–1/2	2⅞	5½	3755	3790

Table 2 continued

Well	Period Averaged Days	Gross Liquid B/D	Net Oil B/D	Circulated Gas Mcf/D	Gross Gas Mcf/D	Casing Pressures psig Max.	Casing Pressures psig Min.	Tubing Pressures psig Max.	Tubing Pressures psig Min.	Trap Press. psig	Cycles per Day	Oil Gravity °API	Casing Gas Gravity Referred to Air	Choke or Bean Setting inches	Tubing & Casing Sizes to Footpiece Inches, OD Tbg	Tubing & Casing Sizes to Footpiece Inches, OD Csg	Plunger Footpiece Depth Ft	Tubing Depth Ft
8	21	61.4	61.0	0	438	119	110	84	82	68	151	41–42	0.690	5/8	2⅞	6⅝	3395	3407
9	21	11.4	11.3	0	642	117	105	82	70	70	163	34–35	0.655	Open	2⅞	7	2252	2308
10	21	23.5	23.5	0	188	390	358	345	59	48	21	40	0.675	3/4	2⅞	5½	5053	5101
11	153	110	110	0	418	320	300	260	90	60	120	35	0.8	—	2⅞	7	6325	6355
12	61	55	55	0	154	360	350	310	110	70	40	35	0.8	—	2⅞	7	6250	6280
13	—	—	11	0	50	210	160	—	20	20	30	40	—	48/64	2⅞	7	7801	7811
14	—	—	22	0	150	450	400	400	150	10	14	40	—	31/64	2⅞	7	7335	—
15	—	—	20	0	150	260	220	220	50	10	11	38	—	1	2⅞	7	8560	8600
16	1	13.8	11.6	96.0	286.3	300	255	175	80	85	22	33.7	0.629	32/64	2⅞	7	11385	11390
17**	1	23.5	18.8	96.0	262.2	260	230	225	80	85	31	28.7	0.629	32/64	2⅞	7	11385	11390
18	31	36	20	81	207	190	170	—	82	82	63*	35.0	0.789	32/64*	2⅞	7	6519	6547
19	31	18	17	75	322	210	190	—	81	81	60	35.5	0.789	32/64*	2⅞	7	6629	6659
20	31	25	24	0	176	140	120	—	82	82	43	31.5	0.780	32/64*	2⅞	7	6583	6615
21	31	35	29	147	288	200	180	—	85	85	75	29.5	0.789	32/64*	2⅞	7	7605	7635
22	123	37	35	0	456.5	138	128	105	60	60	72	30	0.70	1/2	2⅞	7	5988	6008
23	31	29	29	130	165	760	700	600	300	200	13	21	0.62	1/4	2⅞	7	6974	9647
24	30	40	39	363	484	840	760	750	550	480	32	40.0	0.685	48/64	2⅞	7	8800	9658
25	30	60	32	398	464	475	435	400	100	75	45	36.2	0.685	19/64	2⅞	7	7989	9246
26	30	10	9	105	110	475	410	420	160	75	17	34.8	0.685	15/64	2⅞	7	7457	7457
27	—	58	33	207	252	150	135	100	30*	20*	50	27	0.670	1	2⅞	8⅝	4774	4774
28	4	28	22.2	68.5	103	339	299	261	79	63	22.8	24.8	0.688	48/64	2⅞	7	6425	6486
29	3	98	98	425	650	532	484	425	100	56.4	46	31.9	0.688	48/64	2⅞	7	9174	9206
30	3	21	21	154	210	296	260	265	74	—	25.7	27.5	0.688	40/64	2⅞	7	9964	10028
31	6	59.6	59.6	159.5	195	370	334	277	70	62	27	28.3	—	48/64	2⅞	7	9690	9721
32	3	36.7	36.7	182	248	357	320	300	88	54	31	30.0	—	48/64	2⅞	7	9092	9156
33	1	16	11	0	70	330	295*	220	30*	25*	13	34.3	0.701	40/64	2⅞	7	7610	7670
34	1	13	12	0	153	240	205*	200	30*	25*	35	33.1	0.706	40/64	2⅞	7	8609	8669
35	1	6	5	0	54	190	155*	170	30*	25*	11	35.0	0.690	42/64	2⅞	7	8477	8537
36	1	27	25	0	197	250	215*	220	30*	25*	41	33.0	0.706	40/64	2⅞	7	8100	8160
37	30	22.7	22.3	0	200	100	85	80	45	42	84	36.5	0.715	36/64*	2⅞	7	5750	5750
38	30	50.5	33.1	271	331	520	480	400	85	50	26	31.6	0.700	34/64	2⅞	7⅝	10963	11678
39	31	51.5	40.8	159	271	470	440	380*	85	50	33	32.0	0.695	16/64	2⅞	7⅝	11300	11727
40	30	39.8	32.2	139.6	207	475	430	400	85	50	25	35.0	0.695	17/64	2⅞	7⅝	11198	11638
41	31	35.0	32.0	130	170	340	300	250	75	70	26	24.0	0.692	24/64*	2⅞	7	9706	9706
42	31	33.0	31.0	270	300	450	310	380	100	70	26	26.0	0.692	24/64*	2⅞	4¾	9707	9707
43	31	62.0	60.0	0	220	650	570	550	120	70	24	30.0	0.681	24/64*	2⅞	7	8209	8209
44	31	11.0	6.0	0	90	300	270	280	75	70	14	33.0	0.751	24/64*	2⅞	7	10201	10201
45	31	11.0	6.0	0	110	290	250	270	75	70	17	33.0	0.732	24/64*	2⅞	7	9511	10276
46	31	20.0	16.0	0	130	300	260	270	80	70	22	28.0	0.724	24/64*	2⅞	7	10472	10472
47	31	70.0	24.0	150	375	560	500	475	120	70	30	28.0	0.692	24/64*	2⅞	7	10189	10189
48	31	90.0	10.0	0	460	740	660	650	300	70	31	42.0	0.735	24/64*	2⅞	7	10013	10444
49	31	54.5	48.4	0	176.7	280	260	223	104	85	57	29	0.71	24/64	2⅞	7	4717	4717
50	31	37.3	35.6	0	55.0	653	623	560	400	85	12	29	0.75	24/64	2⅞	7	4859	4871
51	31	41.5	40.5	0	83.8	724	684	630	350	85	27	30	0.74	12/64	2⅞	7	4755	4758
52	2	84	83	355	780	715	655	645	160	—	22	36.4	—	—	2⅞	7	9344	9753
53**	6	84	82	60	254	740	680	700	120	—	19.4	36.4	—	—	2⅞	7	9344	9753
54**	3	84	83	0	184	750	690	630	140	—	17	35.6	—	—	2⅞	7	9344	9753
55	3	69	68	0	245	750	680	640	100	—	19	37.3	—	—	2⅞	7	9255	9771
56	3	62	60	100	160	670	605	550	60	—	17	34.6	—	—	2⅞	7	9365	9874
57	8	64	62	93	204	720	660	625	90	—	15	34.4	—	—	2⅞	7	9349	9842
58**	4	71	69.1	101	200	710	640	620	100	—	16.4	34.9	—	—	2⅞	7	9349	9842
59**	3	69	68	92	181	740	680	610	90	—	16	34.0	—	—	2⅞	7	9349	9842
60**	5	70	69	105	235	640	580	530	90	—	21	34.0	—	—	2⅞	7	9349	9842
61**	6	71	69.7	67	141	580	530	440	65	—	17	33.9	—	—	2⅞	7	9349	9842
62**	1	57	54	25	303	770	670	—	65	53	13	39.0	0.678	—	2⅞	7	9349	9842
63	1	47	46	29	209	800	720	—	50	50	10	36.4	0.678	—	2⅞	7	9836	9867
64**	1	47	46	3	183	800	720	545	50	70	8.7	36.4	0.678	—	2⅞	7	9836	9867
65	8	28	27	53	102	620	550	520	70	—	8	34.5	—	—	2⅞	7	9063	9063
66	4	76	72	53	163	750	680	640	100	—	4	34.9	—	—	2⅞	7	9782	9804
67	4	59	57	112	175	720	620	640	100	—	15	33.0	—	—	2⅞	7	9927	9938
68	4	67	62	102	179	690	625	570	90	—	16	34.4	—	—	2⅞	7	9960	9987
69**	4	64	58.5	84	161	650	600	535	160	—	19	30.1	—	—	2⅞	7	9960	9987
70	4	25	21	69	123	735	655	640	90	—	6	32.4	—	—	2⅞	7	10876	10906
71	5	32	30	54	112	760	660	700	110	—	10	34.4	—	—	2⅞	7	9855	9855
72**	3	39	37	0	90	750	650	660	70	—	10	34.8	—	—	2⅞	7	9855	9855
73	3	62	60	0	126	720	650	670	140	—	13	36.5	—	—	2⅞	7	9900	9921
74	10	18	18	36	92	570	490	560	200	—	8	33.4	—	—	2⅞	7	10016	10048
75**	1	12	11	43	74	680	590	—	80	61	4	34.1	0.678	—	2⅞	7	10016	10048

*The data sheets were received with each of these items listed as "approximate" or "estimated."

**A well so marked is the same well as the one directly above, but the data are for a different well condition.

TABLE 3. Ranges[1] and Averages of Well Data.

	2-In. Plunger Low	2-In. Plunger High	2-In. Plunger Average	2½ In. Plunger Low	2½ In. Plunger High	2½ In. Plunger Average
Tubing depth, ft	3,050	11,670	6,677	3,407[2]	11,727	8,313
Tailpipe, ft	0	138[3]	32	0	1,257[4]	185
Production rate, B/D	4.2	63.2	18	10	110	45
Size load, B/Cy	0.1	2.9	0.7	0.2[5]	5.4	2.0
Oil gravity, °API	35[6]	50	38.0	24[7]	46	33.7
Water cut, percent	0	86.7	17.0	0	88.9	12.6

Footnotes from Table 3

[1]The variables ranged fairly uniformly between the low and high values listed, except as indicated below.

[2]One well with 2½-in. plunger had a tubing depth of 2308 ft.

[3]One well with 2-in. plunger had a tailpipe of 417 ft.

[4]One well with 2½-in. plunger had a tailpipe of 2673 ft.

[5]One well with 2½-in. plunger had a size load of 0.07 bbl/cycle.

[6]One well with 2-in. plunger had an oil gravity of 26.5 °API.

[7]One well with 2½-in. plunger had an oil gravity of 21 °API.

FIELD PROVEN

C. T. P. GULFCO'S NEW CONSTANT TUBING PRESSURE AUTOMATIC CHOKE

C.T.P. flows and controls your well automatically within the limits of the minimum and maximum positive chokes.

Each well will operate on the best combination of chokes to suit the particular well . . . from sizes 3/64" to 1/2". Maximum and minimum chokes are easily changed when necessary.

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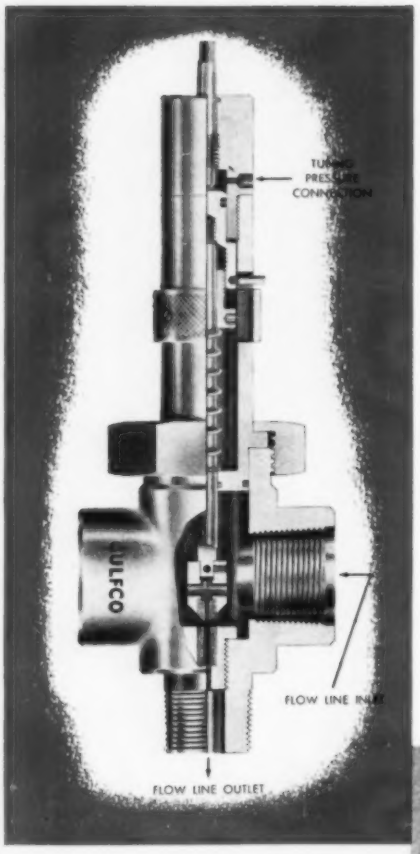
A tee or an ell in the flow line is removed and replaced with the C.T.P. cross and a tubing pressure line is connected to the C.T.P. control head. Operator then adjusts the spring tension to the desired tubing pressure he wishes to maintain on his well. The C.T.P. Automatic Choke does not require two wings on the tree. None of the essential parts of the tree are removed. The original choke body may remain on the tree if desired.

Trouble-free automatic regulation: To decrease the amount of fluid being produced, the operator would lessen the spring tension, which means that the well will flow on or near the minimum choke until the tubing pressure declines to the set spring tension. When the spring tension is greater than the tubing pressure the flow will increase in proportion to the decline in tubing pressure. **The Gulfco C.T.P. Automatic Choke can be adjusted to produce the exact allowable without shutting in the well.**

The design of the minimum and maximum choke is such that, if desired, the difference in diameter can be as small as 1/64".

If he so desires, the operator can also use the manual control as he would with adjustable chokes—down to the minimum choke size.



Gulfco C.T.P. Automatic Choke operates on any type of well – High or Low Pressure

In low pressure wells, or wells that produce excess water or that have a tendency to load up and die, the Gulfco C.T.P. Automatic Choke will keep the well unloaded or flowing. This obviates the fear that operators have of the well dying when put on a smaller choke. The operator can reduce the flow rate with complete confidence.

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2. Adjustments are visible and can be made while the well is flowing.
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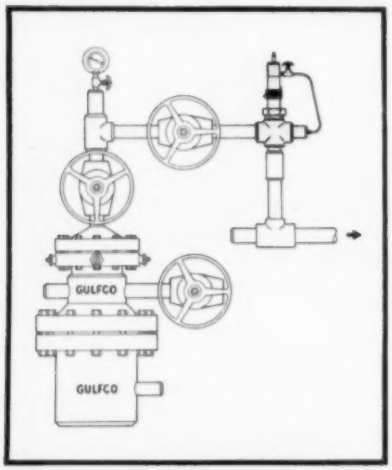

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Donald G. Knox *is gas lift engineer for the National Supply Company at Los Angeles, California. He has worked with National since 1936 when he was first employed in field service and sales. He received his formal education at the University of Oregon and the University of California, Berkeley. Wide field experience enabled him to spearhead the development of equipment related to oil production by gas lift. As a specialist in this field, he is credited with introducing many of the modern oil-producing techniques used today.*

John H. Stoddard *(deceased), former sales engineer for the National Supply Company, died February 20, 1958, after several months' lingering illness resulting from an accident. In 1938, he received a BS degree in Commerce from Northwestern University. During World War II, he was a bomber pilot with 35 missions over Japan, attaining the rank of captain. After the war, he joined National and in 1952 was appointed sales engineer in gas lift. He became recognized as an expert in this field and was instrumental in gas lift developments in California, Wyoming, Texas, and several Mid-Continent states.*

EQUATIONS

Main items of interest in the operation of the gas-lift plunger for a given well are the requirements of net operating pressure and gas-liquid ratio. It is also important to be able to estimate the (casing) pressure build-up and the maximum production rate.

A knowledge of pressure build-up is useful because the net operating pressure depends upon the maximum casing pressure, while the production rate depends upon the average casing pressure. And, these pressures differ by one-half the pressure build-up. The maximum production rate is needed as one limit to the large number of operating conditions that may be used.

It will be shown how the following six basic equations concerning gas and pressure were derived from correlations of field data by the method of least squares. The method of obtaining the two equations for maximum production rate also will be explained.

Net Operating Pressure

$$2'': \overset{max}{P_c} - \overset{min}{P_t} = 77.7\,L_e + 8.29\frac{D}{1000} + 18.08\,L_e\frac{D}{1000} + 67.4 \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$2\tfrac{1}{2}'': \overset{max}{P_c} - \overset{min}{P_t} = 3.44\,L_e + 5.78\frac{D}{1000} + 11.11\,L_e\frac{D}{1000} + 91.4 \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Gas-Liquid Ratio Gradient

$$2'': \frac{G/L}{D/1000} = \frac{9.90\,(D/1000) + 0.774\,\overset{min}{P_t} + 279}{L_e} + 201 \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$2\tfrac{1}{2}'': \frac{G/L}{D/1000} = \frac{47.8\,(D/1000) + 0.738\,\overset{min}{P_t} + 254}{L_e} + 122 \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Pressure Build-Up

$$2''\text{ in }5\tfrac{1}{2}'': \overset{max}{P_c} - \overset{min}{P_c} = 8.16\,L_e + 3.43\frac{D}{1000} + 0.020\,\overset{min}{P_t} + 9.9 \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$2\tfrac{1}{2}''\text{ in }7'': \overset{max}{P_c} - \overset{min}{P_c} = 3.79\,L_e + 9.31\frac{D}{1000} + 0.051\,\overset{min}{P_t} - 43.7 \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Maximum Production Rate

$$2'': \overset{max}{q} = \frac{1440\,L_e}{1.5\,(D/1000) + 8\,L_e} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

$$2\tfrac{1}{2}'': \overset{max}{q} = \frac{1440\,L_e}{1.5\,(D/1000) + 6\,L_e} \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

NOTE: All symbols defined in section entitled **Nomenclature** at end of Part 1.

METHOD OF OBTAINING EQUATIONS FOR GAS AND PRESSURE

For each size plunger, three basic equations were obtained from correlations of field data by the method of least squares. Theoretical calculations and plots[1] were made only to ascertain which variables were indicated as influencing each factor pertinent to the free piston operation. For net operating pressure, indicated variables were size load, depth, and the product of size load times depth. For the factors, cycle gas gradient and pressure build-up, indicated variables were size load, depth, and minimum tubing pressure.

A (regression) equation was formulated with a factor expressed in terms of the indicated variables. The method of least squares[2] was applied to determine the constant in the equation and the coefficient of each independent variable. These coefficients were then used to compute[2] the coefficient or index of multiple correlation. Throughout the calculations, depths were rounded off so that a table of squares up to 2000 could be used without interpolation.

Values were computed for the differences between actual

[1]References given at end of article.

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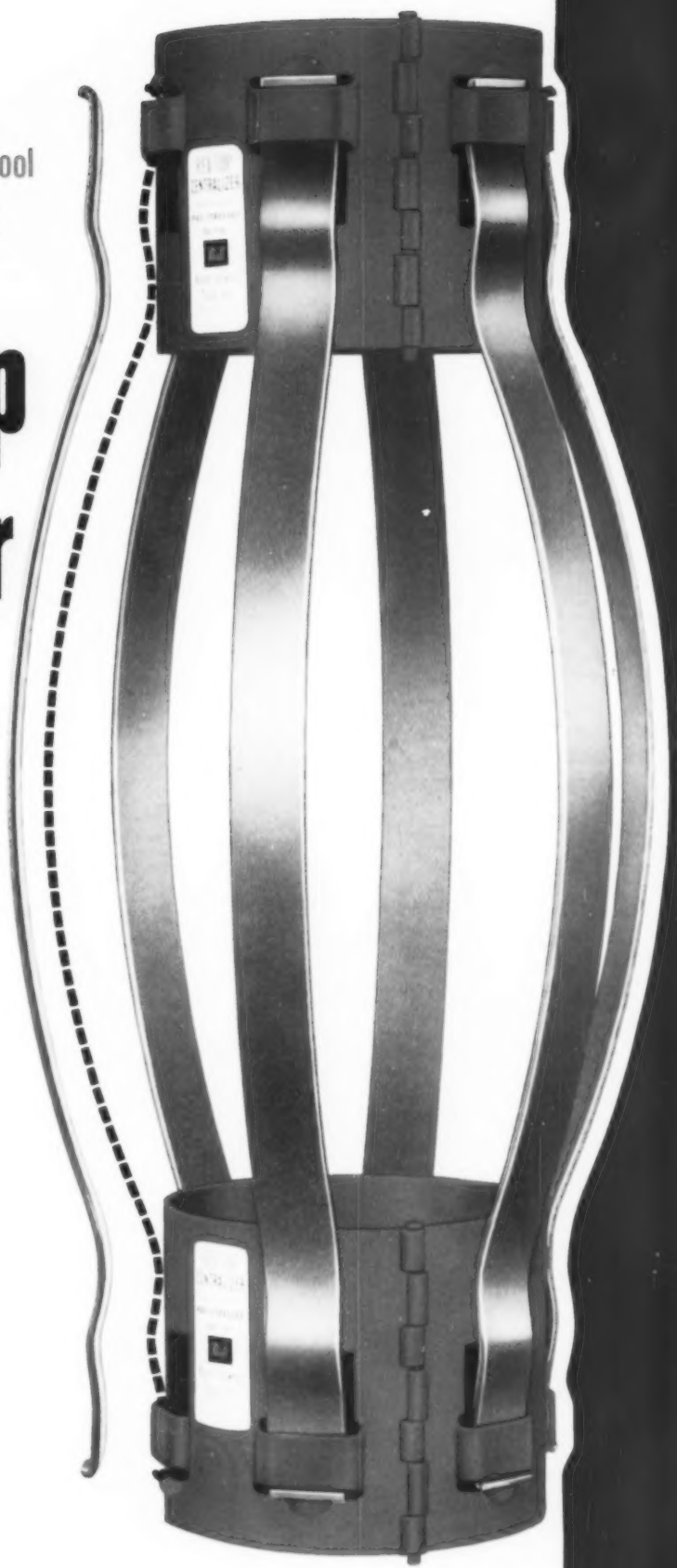

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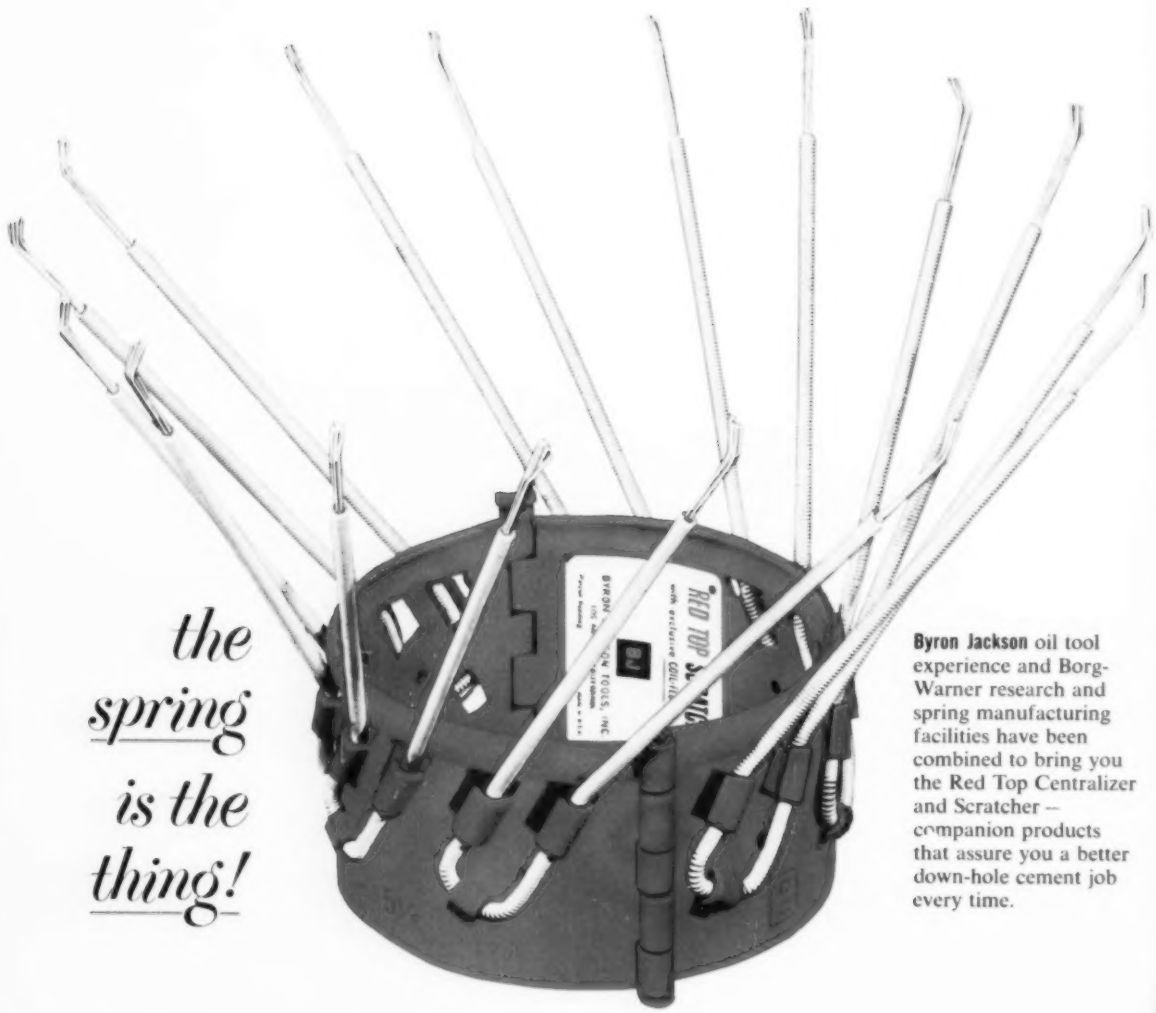

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data and amounts computed from equations. In the case of net operating pressure for the 2-in. plunger and the cycle gas gradient for the 2½-in. plunger, the difference for one well was at least five times the average difference. Accordingly, data for that well was disregarded[3] and coefficients were determined again, using data for all of wells except that one.

As applied to curve fitting, the principle of least squares states that the most probable empirical equation is the one for which the sum of the squares of the residuals is a minimum. A residual is the difference between the amount required by the equation and the observed value.

An equation obtained by the method of least squares represents the most probable values of a dependent variable for different values of the chosen independent variables. For a chosen set of independent variables, values of the dependent variable need not be exactly equal to average values. Accordingly, the sum of the positive residuals need not exactly equal the sum of the negative residuals. Nevertheless, a comparison of the plus and minus sums of the residuals may be used to show that an equation substantially represents average values.

No figures have been included to show that the equations represent averages of the data, since four dimensions would be required for most cases. There have been listed, however, the plus and minus sums of the residuals. Since the sum of the positive residuals and the sum of the negative residuals are nearly equal in every case, it follows that the equations substantially represent averages of the data.

Wells with 2-In. Plungers

The equation for net operating pressure was determined in the form given previously:

$$\overset{max}{P_c} - \overset{min}{P_c} = 77.7\,L_c + 8.29\,\frac{D}{1000} + 18.08\,L_c\,\frac{D}{1000} + 67.4 \quad . \quad (1)$$

Well 53 was disregarded[3] in determining the above equation, since the difference between the reported net operating pressure and that required by the equation obtained by using all of the wells was five times the average difference. Using the 69 remaining wells, the index of multiple correlation was 0.710 (instead of 0.661 for all 70 wells). The positive and negative sums of the residuals were + 2650 and − 2648.

The equation for gas volume was obtained in terms of the cycle gas gradient, and was expressed as follows:

$$\frac{G_c}{D/1000} = 9.90\,(D/1000) + 0.774\,\overset{min}{P_t} + 279 + 201\,L_c \quad . \quad (9)$$

Using all 70 wells, the coefficient of multiple correlation was 0.520. The plus and minus sums of the residuals were + 6887 and − 6901.

Dividing both sides of Equations 9 by L_c yields a relation for gas-liquid ratio gradient based on volumes per cycle:

$$\frac{G_c/L_c}{D/1000} = \frac{9.90\,(D/1000) + 0.774\,\overset{min}{P_t} + 279}{L_c} + 201 \quad . \quad (10)$$

Equation 10, expressing G_c/L_c, is equivalent to Equation 3 given previously in terms of G/L which expresses the ratio of volumes for any interval of time:

$$\frac{G/L}{D/1000} = \frac{9.90\,(D/1000) + 0.774\,\overset{min}{P_t} + 279}{L_c} + 201 \quad . \quad (3)$$

The equation for pressure build-up was obtained as given earlier:

$$\overset{max}{P_c} - \overset{min}{P_c} = 8.16\,L_c + 3.43\,\frac{D}{1000} + 0.020\,\overset{min}{P_t} + 9.9 \quad . \quad (5)$$

The 41 wells with 5½-in. casing were used and the coefficient of multiple correlation was 0.576. The positive and negative sums of the residuals were + 194 and − 197.

Wells 25 through 28 and 34 through 49 had 7-in. casing instead of the usual 5½-in. casing. Accordingly, these 20 wells offered an opportunity of testing the belief that pressure build-up is inversely proportional to the annular areas. The ratio of actual pressure build-up to that required by Equation 5 averaged 0.424.The inverse ratio of annular areas involved is 0.515. Consequently, these results support the belief that pressure build-up is inversely proportional to the annular areas involved, for a given size tubing.

Wells with 2½-In. Plungers

The equation for net operating pressure was determined in the form given previously:

$$\overset{max}{P_c} - \overset{min}{P_t} = 3.44\,L_c + 5.78\,\frac{D}{1000} + 11.11\,L_c\,\frac{D}{1000} + 91.4 \quad . \quad (2)$$

Using the 75 wells, the index of multiple correlation was 0.945. The plus and minus sums of the residuals were + 1849 and − 1981.

The equation for gas requirement was obtained in terms of the cycle gas gradient, and is expressed as follows:

$$\frac{G_c}{D/1000} = 47.8\,\frac{D}{1000} + 0.738\,\overset{min}{P_t} + 254 + 122\,L_c \quad . \quad (11)$$

Well 52 was disregarded[3] in determining the above equation, because the difference between the actual cycle gas gradient and that required by the equation obtained by using all the wells was almost eight times the average difference. Using the 74 remaining wells, the coefficient of multiple correlation was 0.639 (instead of 0.599 for all 75 wells). The positive and negative sums of the residuals were + 9484 and − 9698.

Dividing both sides of Equation 11 by L_c yields an equation for gas-liquid ratio gradient based on volumes per cycle. Analogous to the case of the other size plunger, the latter relation is equivalent to Equation 4 given previously for gas-liquid ratio gradient based on volumes for any interval of time:

$$\frac{G/L}{D/1000} = \frac{47.8\,(D/1000) + 0.738\,\overset{min}{P_t} + 254}{L_c} + 122 \quad . \quad (4)$$

The equation for pressure build-up was obtained as given earlier:

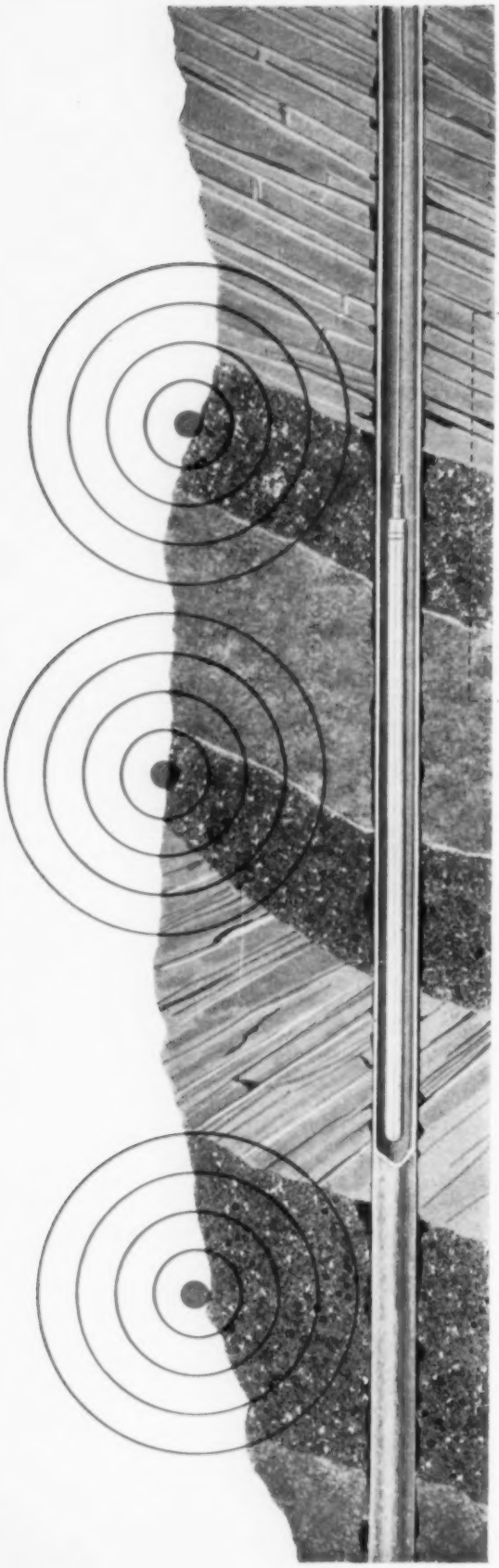
$$\overset{max}{P_c} - \overset{min}{P_c} = 3.79\,L_c + 9.31\,\frac{D}{1000} + 0.051\,\overset{min}{P_t} - 43.7 \quad . \quad (6)$$

The 61 wells with 7-in. casing were used, and the coefficient of multiple correlation was 0.837. The plus and minus sums of the residuals were + 415 and − 417.

EQUATIONS FOR MAXIMUM PRODUCTION RATE

The minimum cycle time involves movement of the plunger from the footpiece to the surface, unloading the liquid at the surface, and movement of the plunger from the surface to the footpiece. In addition, the last step might be divided into the fall of the plunger through gas to the top of the liquid and the fall of the plunger through the liquid to the footpiece. From these considerations, it seems reasonable to suppose that the minimum cycle time depends mainly upon the depth to the footpiece and on the size load.

If a tailpiece is used. When the well has a tailpiece, extra time is required for the gas to break through the slug of



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An electric log, run in this shallow Illinois oil well, proved of no value to the operator. Log curves were not detailed—thin sands were missed entirely.

McCullough's Radiation Well Logger was run, obtaining simultaneous Gamma Ray-Neutron Curves and a Collar Log. Thin sands were easily located from the detailed log. Correlation with core data was exact.

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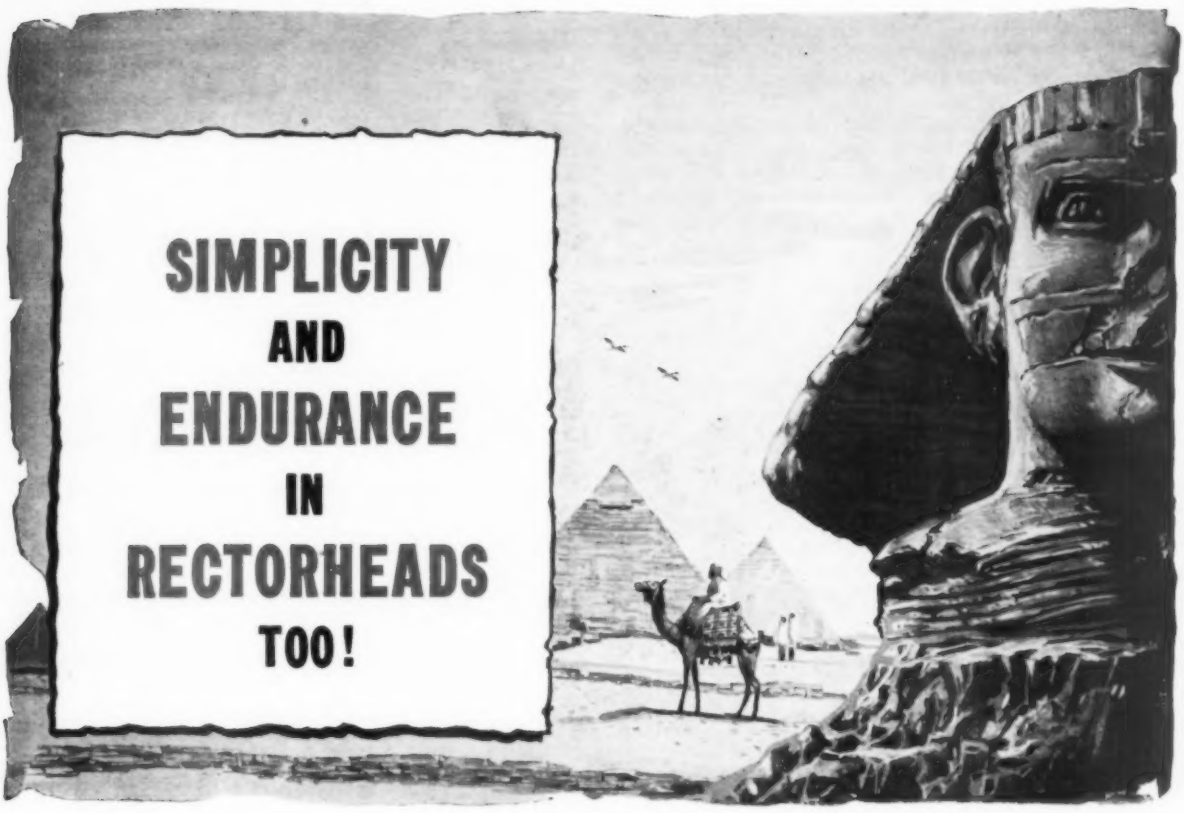

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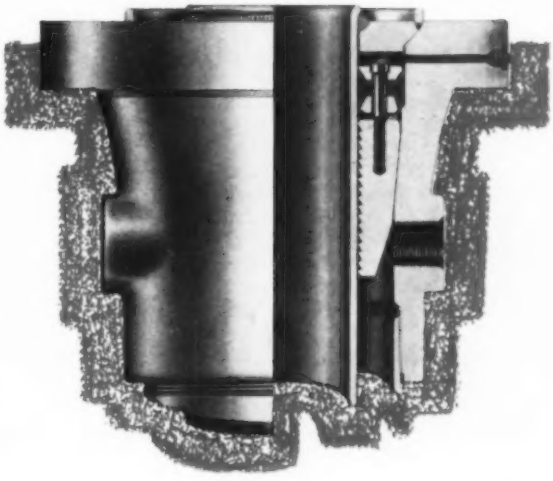

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liquid below the footpiece. This extra time appears to be about equivalent to the time required for the plunger to rise and fall through gas for a distance equal to the length of the tailpipe.

For wells with tailpipes, therefore, the depth affecting the cycle time may be taken as the depth to the bottom of the tailpipe. More generally, the depth may be taken as the point where gas enters the tubing. This also is the depth found to be most suitable for computing the gas and pressure requirements.

Cycle time. The operating conditions ordinarily are set so that rate of upward movement of the plunger averages about 1000 ft per minute. The downward fall through gas is about twice that speed. Accordingly, the number of minutes required for the plunger to rise to the surface and fall to the top of the liquid may be expressed as one and one-half times the depth in thousands of feet.

Measurements and estimates of the time required for the plunger to unload liquid at the surface, and for the plunger to move down through liquid in the tubing, lead to a value in minutes equal to eight times the number of barrels per cycle for the 2-in. plunger and six times the number of barrels per cycle for the 2½-in. plunger.

These considerations lead to expressions for the minimum cycle time. Then equations may be readily obtained for the maximum production rate expected. This involves dividing the number of minutes per day by minimum cycle time and multiplying by load size. The relations are:

$$2'': \overset{\min}{t_c} = 1.5\,(D/1000) + 8\,L_c \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

$$2\tfrac{1}{2}'': \overset{\min}{t_c} = 1.5\,(D/1000) + 6\,L_c \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

$$2'': \overset{\max}{q} = \frac{1440\,L_c}{1.5\,(D/1000) + 8\,L_c} \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

$$2\tfrac{1}{2}'': \overset{\max}{q} = \frac{1440\,L_c}{1.5\,(D/1000) + 6\,L_c} \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Of the data received and listed in Tables 1 and 2, 10 wells correspond to rates of production that exceed 70 percent of the values computed from Equations 7 and 8. For Wells 3, 25, 26, 28, 29, and 37 with 2-in. plungers, the respective production rates were 73.7, 115.3, 119.2, 72.3, 73.5 and 73.5 percent of the values computed from Equation 7. For Wells 3, 6, 29, and 48 with 2½-in. plungers, the respective production rates were 70.3, 92.5, 85.0 and 71.2 percent of the values calculated from Equation 8. These comparisons indicate that the rates expressed by Equations 7 and 8 are not too difficult to attain.

Nomenclature

D = depth or distance from surface to point at which gas enters tubing, ft.

G/L = volume ratio of gross gas to gross liquid, both measured at 14.7 psia and 60 F, std cu ft per bbl.

G_c = volume of gross gas per cycle, std cu ft per cycle.

J = productivity index, bbl per day per psi.

L_c = size load of gross liquid, bbl per cycle.

$\overset{\max}{P_c}$ = maximum casing pressure (at the surface), psig.

$\overset{\min}{P_c}$ = minimum casing pressure (at the surface), psig.

$\overset{\min}{P_t}$ = minimum tubing pressure (at the surface), psig.

P_{wf} = flowing bottom-hole pressure (at depth D), psig.

$\overline{P}_{wf}$ = average flowing bottom-hole pressure (at depth D), psig.

P_{ws} = static bottom-hole pressure (at depth D), psig.

q = gross production rate, bbl of liquid per day.

$\overset{\max}{q}$ = maximum gross production rate, bbl of liquid per day.

$\overset{\min}{t_c}$ = minimum time required for plunger to complete a cycle, minutes per cycle.

$\frac{G/L}{D/1000}$ = gas-liquid ratio gradient, $\frac{\text{cu ft per bbl}}{\text{ft/1000}}$

$\overset{\max}{P_c} - \overset{\min}{P_t}$ = net operating pressure, psi.

$\overset{\max}{P_c} - \overset{\min}{P_c}$ = pressure build up, psi.

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2. Ezekial, M.: *Methods of Correlation Analysis*, John Wiley and Sons, New York, New York (1941).
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TO BE CONTINUED

Part 2 titled "Constructing Nomographs to Simplify Calculations" of this 5-part series will be published next month. The Second Part will demonstrate step-by-step how these nomographs are made for various conditions.

SMS (Texas) Field Seeks Unitization, Flood

Plans for unitization and waterflooding of the SMS field in Kent County are now under study by operating companies there. Pan American Petroleum Corporation would become unit operator if the proposal is adopted.

Engineering studies at the West Texas field indicate that waterflooding would extend field life about nine years, substantially increasing remaining recovery.

Principal operators at SMS now studying the proposal include Pan American Petroleum Corporation, Blanco Oil Company, Honolulu Oil Corporation, Sunray Mid-Continent Oil Company, and the Superior Oil Company.

Discovered in 1954 by Bright and Schiff, the SMS field hit peak production of 3330 bbl of oil a day from 75 wells in April 1956. It has declined gradually since then in ability to produce.

Before waterflooding can commence, the field must be unitized, which means operators and royalty owners must agree to pooling their interests in the field. The field is then operated as a single unit rather than a number of individual leases, allowing the implementation of secondary recovery methods.

What's Behind the Model Form Operating Agreement

Many oil and gas producing properties are joint ventures in which two or more companies or individuals, or both, jointly drill wells. Such joint ventures may come about as a result of the pooling of two or more separate leases into one production unit, or may result where two or more individuals or companies may own undivided interests in the same lease or leases. In any event, the relationship of the parties involved in the operation is usually set forth in a joint operating agreement.

For many years, and up until two years ago, each individual or company involved in a joint venture had its own operating agreement and, of course, preferred to use such agreement. However, due to the fact that much of the substance in these agreements was basically alike (with only the wording being different), it was deemed advisable, and to the best interests of the industry, to create a model form of operating agreement in the hopes that a majority of the industry might be induced to use such model form as the basis for its operating agreements. As a result, a model form operating agreement committee, headed by John H. Folks of The Carter Oil Company, was formed and such a model agreement was prepared.

It would be presumptive on the part of the model form operating agreement committee to expect the industry to use the model form agreement verbatim. However, it is only reasonable and practical to ask that this form be accepted basically by the industry, but with the ever present right and privilege of making such changes in the model form agreement as may be deemed necessary by those parties engaging in a joint operation.

George R. Bixler, Chairman,
Public Information Committee,
American Association of Petroleum Landmen,
BBM Drilling Company,
Houston, Texas.

Some questions and answers on the

Model Form Operating Agreement – 1956

R. L. Hughston,
General Attorney,
Shell Oil Company,
Midland, Texas.

What is the so-called Model Form Operating Agreement—1956?

It is a printed form suggested for use by all operators in connection with agreements for joint operations on non-federal lands. It is not necessarily the ideal form. Many companies will undoubtedly think that their forms for such agreements are superior. Consequently, calling the form a "model" form is a misnomer at least to those who consider "model" to mean "ideal." A more appropriate name would probably find "standard" or "basic" substituted for "model" in it.

What is the origin of the form?

The form is the result of a spontaneous movement which started in Oklahoma City in 1952 for an operating agreement form that would be widely accepted. Men from many companies were involved in drafting it. Several conferences were held, and many years were spent in agreeing on the form. One of the members of the Legal Committee that assisted in preparing the form has advised there were numerous suggestions and advancement of almost every possible approach. He was at first quite dissatisfied with the final form, which he regarded as a compromise, but I understand that he is now using it because of its time saving capacity.

Is there a need for a basic generally accepted joint operations agreement form?

Decidedly so. Unless such a form is widely adopted, it is necessary to read each operating agreement very closely. Matters that are worded differently from the way they are worded in your company's agreement form may be considered unacceptable to someone in your company and negotiations for a change in those respects must be conducted. If several parties are involved in the joint operation, satisfying everyone becomes quite difficult and time-consuming. Certainly the method of

Presented before the Permian Basin Landmen's Association, February 11, 1958, at Midland, Texas.

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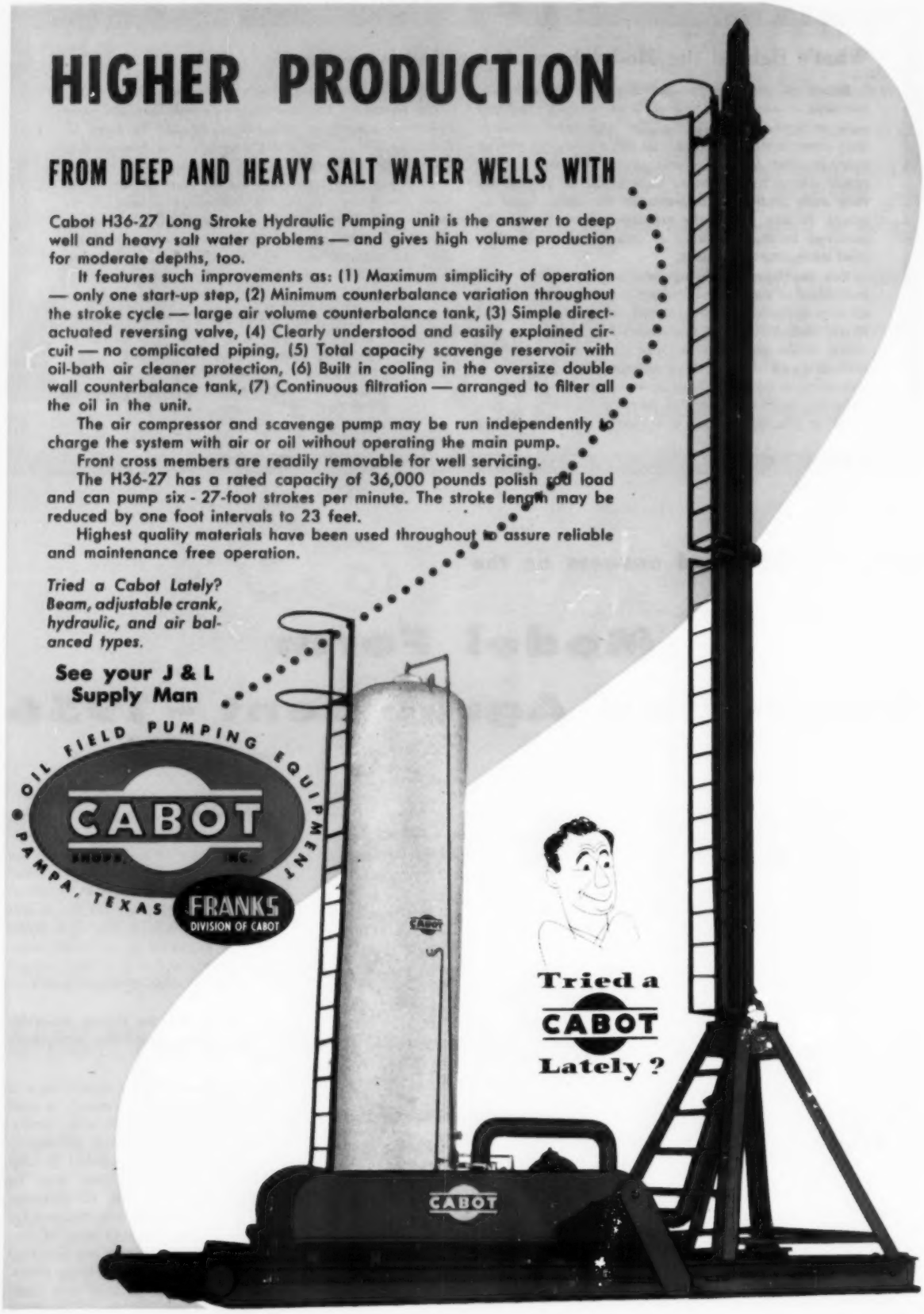

every company having its own form is cumbersome and inefficient. On the other hand, if a known basic form is used for an operating agreement, each party can glance through it to see what, if any, changes have been made in the printed portion, and what, if any, provisions have been added. Such an examination can obviously be made quickly. The effect of the changes and supplements could then be weighed and quickly accepted, rejected entirely or accepted on condition of modification. The matter is made easier for everyone.

Are substantially the same matters covered by the joint operating agreement forms of all companies?

Yes. All operating agreements will usually cover, in some way, although perhaps in a different order, all of the subjects listed in the table of contents to the model form operating agreement, except Section 22, entitled Renewal or Extension of Leases and Section 27, entitled Claims and Lawsuits. The subject of claims and lawsuits is covered in the Paso Accounting Procedure form that is generally attached as an exhibit to operating agreements to establish a basis for settlements.

Doesn't it make sense then that a basic form of coverage of these matters should be accepted even though it is not "ideal" and does not in all respects conform exactly with any one company's practice or form?

Absolutely. Anything that will save the misery of reading and considering every word of every proposed operating agreement and trying to get agreement on how a matter is to be expressed, conserves that much time and mental effort. Any form prepared by a committee must necessarily represent many compromises and cannot be "ideal" to any member of that committee, or for that matter, to anyone else. But, the use of a widely accepted form even if the form is not ideal and must be amended to satisfy the contracting parties, will assist one in speeding agreements to conclusion. Where a party feels that something in a basic form is not acceptable, he can change it by adding a supplemental provision under Section 30, entitled "Other Conditions." Everyone using a basic form should approach it with the attitude of trying to accept each of its provisions unless it is so objectionable that he cannot live with it. If it is approached from that attitude, it will be found that the areas of negotiation are small and that the time of everyone will be conserved.

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For one oil company (name upon request) a Double-Displacement Rod Pump paid out before the test was even completed!

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The Double-Displacement is a traveling barrel, bottom hold-down assembly made up of two plungers and two barrel tubes which work simultaneously with a single set of valves. In operation, the assembly produces as two separate pumps made up in tandem which virtually doubles the volume of the unit — as compared to the displacement of comparable-sized pumps. The Double-Displacement also has the additional operating advantages of an insert-type pump which can be run and pulled on the rods. Hundreds of these pumps are in daily operation throughout the Mid-Continent and Gulf Coast areas, including many water flood projects.

H-F Double-Displacement Rod Pumps are available in a wide range of metal-to-metal, H-F "Flexite,"® or soft packing plungers with chrome-plated or heat-treated barrel tubes in 2"x1½", 2½"x2", and 3"x2½" sizes.

If you think a Double-Displacement Pump might solve the production problems you have been having with your wells — talk to your store, one of our many factory representatives throughout the oil patch, or write to us at P. O. Box 127 in Fort Worth. We'll be glad to send you complete details, illustrated literature, and comparison data without obligation.

NOTE — *This is the original Double-Displacement Pump — marketed by Harbison-Fischer in 1950 . . . not to be confused with imitation pumps which do not measure up to the performance record that hundreds of Double-Displacement Pumps have always enjoyed throughout the oil patch. When you run a Double-Displacement Pump, be sure you get the genuine original.*

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To get a basic or standard operating agreement form widely accepted then, what attitude will be necessary on the part of the members of the oil and gas industry?

Every participant in the industry must recognize that it cannot always get its ideas stated just as it likes. Too many people and ideas are involved. Compromises must be made. The basic form should be generally accepted and only departed from where the matter is considered of importance.

Do we have any other example of a basic form being used in connection with joint operations agreements?

Yes. Accounting procedure forms for joint operating agreements have long been printed in a basic form. The accounting procedure form now most widely used in this connection, the Paso form, was first printed in 1951, as I recall. Before that, there were other printed and widely accepted accounting procedure forms. According to my information, the Paso Accounting Procedure Form was prepared in much the same manner as the Model Operating Agreement Form by a committee of accountants who felt that older forms were outmoded and that a new basic form should be prepared.

Wouldn't a basic form be more widely accepted if endorsed by or prepared by a committee named by an oil and gas association?

Undoubtedly. Many lawyers, however, feel that following that procedure might result in an anti-trust charge against the association. We all recall in this connection that the Attorney General's office took the position that the promulgation of a casinghead gas sales contract by the Natural Gasoline Association of America was a violation of the anti-trust statutes. There is, however, a considerable difference from the anti-trust viewpoint between a casinghead gas sales, which involves buyers and sellers, and the joint operations of oil and gas interests which because of cotenancies are in many cases absolutely necessary. The casinghead gas sales contract form was criticized by the Attorney General as suggestive of the price to be paid for the gas, and as a price fixing arrangement. Forms for operating agreements, however, in no way directly affect prices or lower competition. Under them each party owns and disposes of his share of the product. I doubt that the connecting of an association's name with a joint operating agreement form would bring on a charge of anti-trust violation. However, if some think so, it is necessary to act outside all established associations in order to work with those parties.

Is the form suitable for both "undivided interests" and "divided interests" situations?

Yes. By an undivided interests situation we mean one where the interest of each party is a fractional part of the entire area affected by the joint operations agreement. A divided interests situation is one where the interests of at least some of the parties extends to only part of the total area affected by the agreement. Divided interests agreements are often more elaborate in scope and will usually involve more parties. Quite often provisions for voting and control of operations by a specified majority will be included in such agreements. Also, in divided interests agreements, it is generally provided that losses from the expiration of the term of a lease or from breach of implied covenants shall be borne as joint losses. On the other hand, as to undivided interests, such losses are more often considered individual losses. The model form, Subsection C of Section 2, provides that all losses from such matters shall be joint losses. Where one is dealing with an undivided

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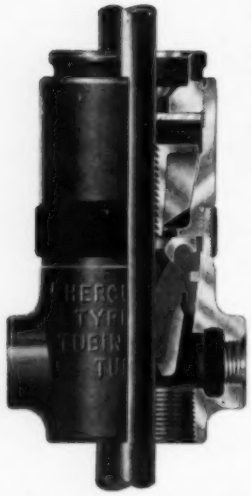

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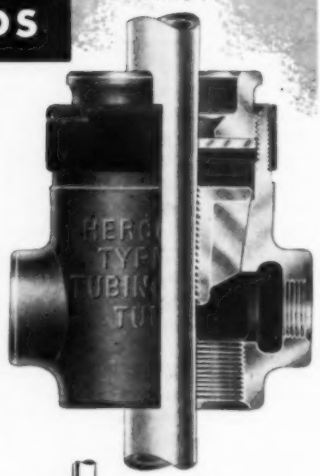

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interest situation, he might delete this provision and substitute therefor a short one providing that those losses shall be considered individual losses.

What is the best way to "tailor" the form to meet particular objections or situations?

By the addition of provisions under Section 30, entitled "Other Conditions." It isn't good draftsmanship to make deletions by lines or other marks on the instrument itself as doubt may arise as to when they were made and as to whether they were approved by all parties. It is much better to provide under Section 30 that a certain section, paragraph, sentence or group of words is to be deleted or replaced by whatever is then set forth.

What provisions will be of particular interest to land men in negotiating an agreement for joint operations?

Subsections A and B of Section 2 and Sections 7 and 12. Section 2 deals with examination of titles and the effect of the loss of a leasehold on the interest of the party to whom that leasehold is attributed. The form has alternate pages 1 and 2 to cover different methods of title examinations and to make loss from a failure of title either a joint loss or an individual loss. Frequently, parties in the Permian Basin agree that no title examination is necessary. When such is the case, Subsection A of Section 2 may be deleted. However, the matter of what title examinations, if any, are to be made is something that should be discussed and agreed upon. If title examinations are not to be made, the parties will usually wish to agree that a loss from title failure is to be an individual loss. If the parties agree that the title failure is to be an individual loss and use the pages of the form so stating, they should consider whether or not to delete Paragraph (5) under Subsection B of Section 2, since that paragraph has the effect of making the part of the loss that occurs prior to the time of the determination of the title failure a joint one. Ordinarily, where an undivided interest situation is being covered by the agreement, the parties will wish to delete that paragraph, while where a "divided" interest situation is being covered, they will wish to leave in that paragraph.

If undivided interests are involved the parties may wish to delete Subsection C of Section 2, and to provide that losses from failure to develop or from the term of a lease expiring or from production being shut-in by reason of lack of a market, shall be individual losses. Where titles are not examined and the parties do not know the terms of each of the other parties' leases, it will undoubtedly be preferred to make such losses individual losses. At any rate, that matter will have to be covered sooner or later and the best time to cover it is when negotiations are first underway.

Section 7 deals with the test well. Obviously, negotiations must be conducted with reference to its depth and financing. If the financing is on any basis other than the prorata basis stated in Section 4, special provisions covering the arrangement must be added to Section 30, entitled "Other Conditions." Occasionally the trade concerning depth will be such that it will not fit the printed portion of the form, part of which may have to be deleted and a substitution made therefor under Section 30.

Section 12 is concerned with operations by less than all parties. It provides for the parties joining in such operations a 200 percent recovery of the cost of the work on the well and of equipment therein to and including the wellhead, but for only a 100 percent recovery of surface equipment beyond the wellhead. I believe that in this area, the Permian Basin, it has been customary to allow a premium recovery as to the entire amount of the well costs including pumping equipment, separators and tankage where their use is a necessary part of the well expense.

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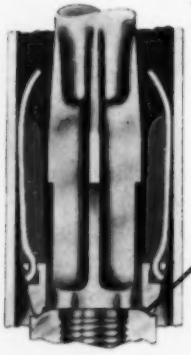

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Some parties may consequently wish to make the agreement so provide. Often, parties will not agree to more than a 150 percent premium as to wells drilled or operations conducted without the consent of all parties, and it may be that the agreement will have to be altered in that connection. At any rate, it would be well to mention these matters early in the negotiations and to reach agreement as to them so that when the contract is prepared it will be in final form.

What are the provisions of the model form to which objections are most often made?

The objection most often heard is that Section 22 conflicts with Section 17. It seems probable that the two sections were intended by the Drafting Committee to cover different situations and that they would rarely conflict if Section 22 were interpreted as applying only to a situation that arises where the term of a lease expires, for Section 17 obviously applies only when the lease terminates as the result of a nonpayment of a delay rental or of a shut-in well obligation. In this connection, note is to be taken of the fact that in Section 22 provision is made for renewal or extension of leases, while in Section 17 provision is made for a "new" lease. However, the distinguishing feature of the application of the two sections is not clear and where undivided interests are involved one can easily avoid the difficulty by deleting Section 22 entirely. Where there is a divided interest situation, one might clarify the possible conflict by adding an additional provision to Section 30.

Where the unit area is of sufficient size and the interests are divided, demand will probably some day be made that provision be made for control of major expenditures by a vote of a certain size. This bridge can, of course, be crossed when it is reached. In most situations, I believe that most operators had rather rely on the protection afforded them by the provision for operations by less than all parties than to be bound absolutely by a vote of a certain size.

By way of a summary, the use of a standard form for joint operating agreements is obviously greatly to be desired. It would save countless hours of work and reduce haggling over language to a minimum. The so-called Model Form Operating Agreement was prepared for the purpose of being such a standard form. While it may not be ideal and will require some alteration or addition in every case, it has a much better chance of wide acceptance than does any company form. I wholeheartedly recommend the adoption of its use by your company or employer.

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Field-proved in Canada . . .

New Technique Tests Casing in the Hole

. . . But, before cementing operation. Over 1 million ft have been field tested by Canadian operators. Faulty joints can be replaced prior to cementing

Larry C. M. Darling,
Macro Limited,
Calgary, Alberta, Canada

A SIMPLIFIED and practical technique for testing casing just prior to cementing has been developed and field proved by Macro Limited of Calgary, Alberta, Canada. Referred to by the abbreviation, CFE, for casing failure elimination, this method has been used to field test over 1 million ft of casing after it has been run in the hole and before cementing operations.

How it works. The idea includes a drillable seat which is located in the casing string just above the float collar or cementing shoe. The casing is run and the well circulated in the conventional manner. A plug which fits into the drillable seat is dropped into the casing to seal it at the bottom, as shown in Fig. 1. With the lower end of the casing string sealed off, it can be pressured tested prior to cementing.

A pressure test can be made at any time desired so that all or a portion of the string can be tested as the string is run. Should a leak be detected, the casing can be pulled and the faulty joint replaced.

After a satisfactory casing pressure test, the plug is retrieved by a sand line or wire line and the casing can then be cemented in the usual manner.

Operation Hazards

The first test was done in the fall of 1956. Exceptionally few troubles were encountered in field proving the method, and to date over 25 percent of all the production strings run in Canada utilize this casing testing technique. It is particularly practical in areas wherein hydraulic fracturing, acidizing, and other high-pressure workover operations are contemplated.

It was originally thought that the "heaving" formation problem would limit use of this method to areas where this problem is at a minimum. Operators reasoned that the casing could not be pulled out of the hole should a leak be detected. It has been found that the new low-water-loss and oil base muds have almost eliminated this problem.

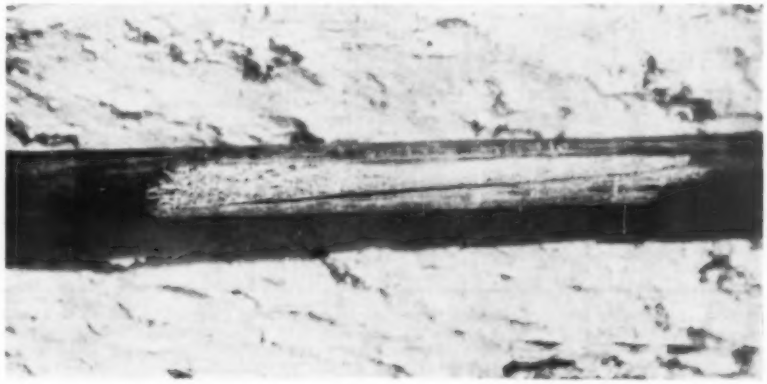
The operation usually takes about one hour rig time. The casing is not circulated during this time. It has been found that it is desirable to circulate the casing annulus before running the test in order to condition the hole.

Advantages of method. The simplicity of operation and the positive results point up a number of advantages, among which are:

1. The operation is extremely simple, and therefore, cheap. For example, a 5000-ft casing string costs about $250 to test after it has been run in the hole.
2. A faulty joint is replaced on the spot rather than repaired.
3. Couplings are tested in-place, as well as the joints, and under the same test conditions.
4. The pressure test is performed on the casing string as it will be used in its final position in the well.
5. Testing can be done in stages while running the casing into the well.
6. Adequate testing in the field under final well conditions may permit the use of lighter-weight casing at an additional saving to the operator.

Performance to Date

In 205 wells, 1,035,250 ft of production casing were tested to March 31,



Split in casing discovered by casing failure elimination method. After test, casing was pulled, faulty joint replaced, string run back in well, tested again, and then cemented in place

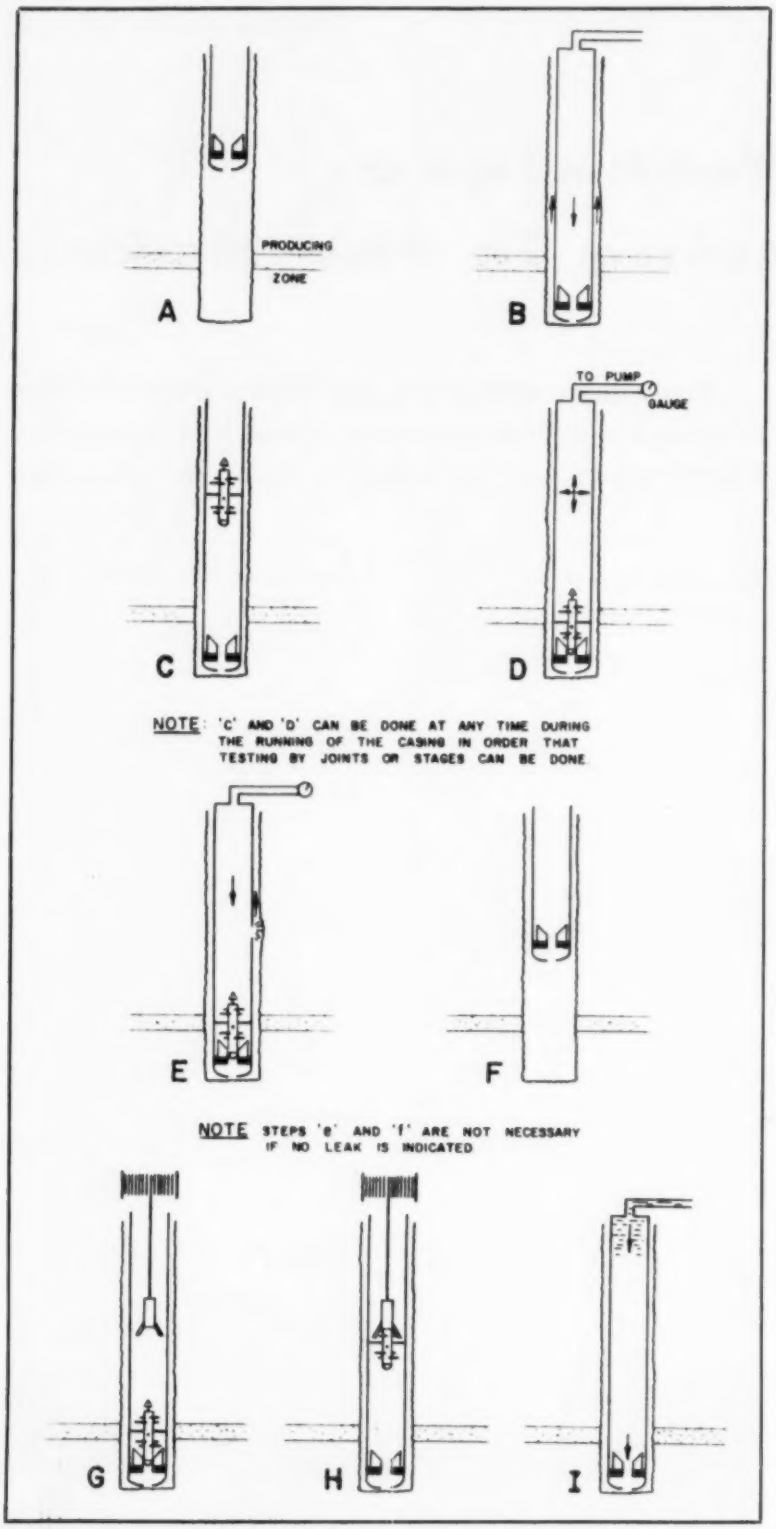


FIG. 1. Simplicity and practicability are key features of the new casing testing technique field-proved in Canada. Here are the steps involved: (A) Running casing joint-by-joint with drillable seat in position; (B) with casing on bottom, drilling fluid is circulated down casing, up annulus; (C) seal plug falls through drilling fluid in casing; (D) with plug sealing casing, pressure test is made; (E) if faulty joint is indicated; (F) casing is pulled and replaced; (G) if test is satisfactory, wire line overshot recovers cylindrical seal plug; and (H) plug is pulled from casing; (I) casing is cementing in normal manner.

The Author

Larry C. M. Darling *is president and general manager of Macro Limited with headquarters at 315 Eighth Avenue West, Calgary, Alberta, Canada. He is a petroleum engineer with a bachelor of science degree. He attended the University of Alberta and the University of Texas. Prior to forming his present company, he practiced petroleum engineering and geology in Alberta and Saskatchewan.*

1958. The holes varied in depth between 10,850 and 3500 ft, the majority being approximately 5000 ft. Twenty percent of the strings tested were done in "stages" while running in the hole, and all the strings tested were new pipe (used pipe not included in this report).

Seven casing failures (photo Page B-119) were detected and these were replaced at an average cost of $800 each. Failures were found at depths varying between 750 and 4200 ft and were indiscriminate as to manufacturer, weight, grade or range.

The pressure used in testing was 85 percent of the listed (API) internal yield pressure in all but 22 of the tests. The remaining 22 indicated no failures and the pressures used were from 50 to 84 percent of the listed (API) internal yield pressure.

Availability

The tool and service is rented to oil operators by licensed oil well service companies, who provide the personnel and equipment necessary for the job. Ordinarily, a high pressure-volume pump is available on the lease for cementing purposes and this is used for the test. No license has been granted for this service to be offered in the USA as yet, however it is expected to be made available in all major areas within the next two months.

Savings are impressive. An estimated $250,000 in tangible savings have been realized by Canadian operators through the use of this method in its first year of operation. The 3.3 percent failure which has been located indicates there is possibly a greater number of wells than is generally presumed of having faulty casing. Intangible savings are incalculable, but could be extremely large (loss of production, loss of a hole, failure to locate a field etc.) Testing casing by this method can be warranted by the savings realized.

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1. "Oilwell Casing and Tubing Troubles," H. G. Texter, API, January 1956.
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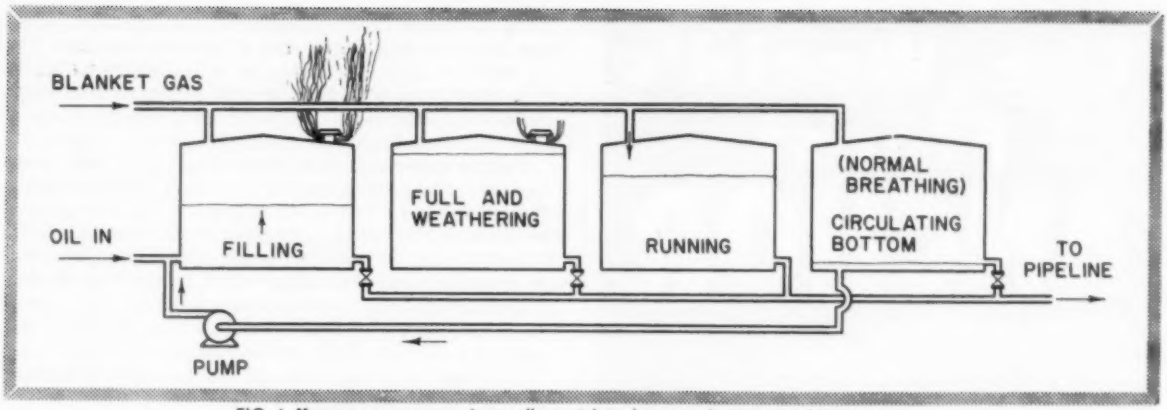

FIG. 1. **Vapor recovery system** collects rich tank vapors during normal battery operating routine. Tanks are alternately filled, weathered, run, and the bottom circulated.

In Vapor Recovery . . .

Evaporation Loss Becomes Production Gain

Installation of vapor recovery system minimizes evaporation in tank filling and weathering, results in plant recovery increase of 10,000 gal per day

R. E. Fields,
The Atlantic Refining Company, Dallas, Texas

THIS IS AN ANALYSIS of how a substantial stock tank evaporation loss in Atlantic Refining Company's Block 31 field was eliminated by a vapor recovery installation. It is an example of one case where field-wide planning brought evaporation control with a gratifying increase in revenue.

Block 31 field was a good potential for evaporation control. A disadvantage was widely spaced storage facilities. But, about two years ago, it was noticed that tank corrosion throughout the field would eventually require replacement of storage facilities. Solving the storage problem would set up a natural opportunity for vapor loss control.

Description of Field

Block 31 is located in the sand and mesquite country in Crane County, West Texas, about 30 miles south of Odessa. It is a prolific oil field with several producing formations. Principal production is from the Devonian formation, producing with the assistance of a gas pressure maintenance program. Only the Devonian production is concerned with vapor control.

The Devonian wells produce from a depth of about 9000 ft. Average gas-oil ratio is 1400 cu ft per bbl, API gravity is around 47 deg, and the Reid vapor pressure is over 10 psi, even after stage separation and treating. With a full pressure maintenance program, the producing rate is about 15,000 bbl per day. Block 31 is unitized with Atlantic Refining Company as the operator, so the whole field could be considered as a package.

Vapor Recovery Opportunity

Tankage problem. It appeared that all the Devonian tanks would need replacement within a year. Since there were 62 tanks, and the reservoir is expected to produce for a long time, this problem was considered carefully. Since the estimated replacement cost of $270,000 was very high, possibilities for one large central tank battery were investigated. Centralization of storage would also present the oppor-

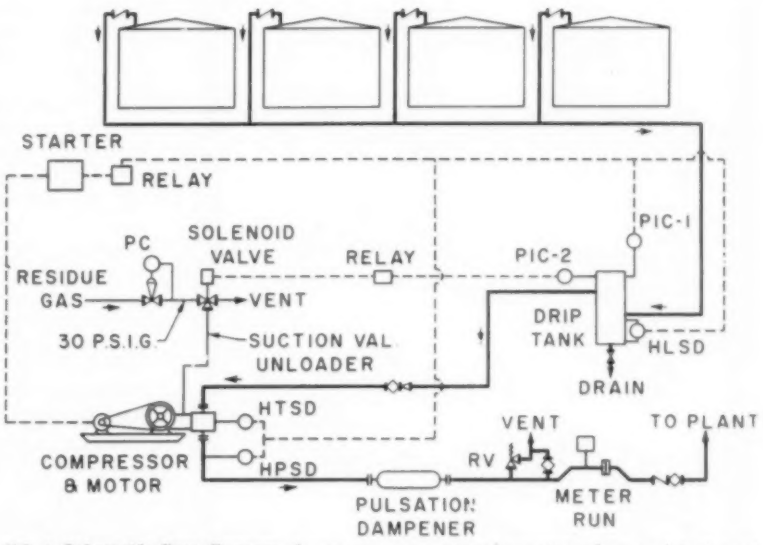

FIG. 2. **Schematic flow diagram** of vapor recovery system shows piping from each tank manifolded to compressor. Suction is slightly over atmospheric pressure and discharge is at 10 psig.

Based on paper entitled "Vapor Recovery Turns Oil Production Loss Into Profit," presented by author at the Spring Meeting of the API Evaporation Loss Committee in Houston, Texas, May 6, 1958.

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tunity for vapor recovery. However, the cost of re-laying flow lines was prohibitive. Use of existing flow lines and separation stations and laying an oil-gathering system to these separate states was considered. Study of field maps showed that everything needed for the project, except a large battery of tanks, was already in place.

Pipeline gathering system. Because of the desirable composition of this particular crude for refining processing, the pipeline company had a separate gathering system from the Devonian batteries to a terminal at the south side of the field. This allowed them to gather and deliver Devonian oil without mixing with other oil. It was decided to buy this gathering system and produce directly into it from treaters and separators and to build tanks at the end of this system between the leases and the pipeline terminal.

Only slight revision of the gathering system was necessary. A new section of line was laid to serve three operators not in the unit, and a section of line was extended to one location.

Disposition of vapors would be to the pressure maintenance plant, less than a mile from the central battery location. The plant was being enlarged to include full gasoline plant facilities and was scheduled for completion a little before collection of vapors would begin.

Preliminary economics. Compared with replacing and maintaining tanks in their original locations throughout the life of the field, the central tank battery would have a present-worth advantage of over $100,000.

Problems. It was necessary to assure flow into the central battery with the available operating pressure of the treaters and head due to the location of the separation stations. Levels were run and adequate head was found to overcome friction and flow into high tanks. With tankage removed from each lease, metering would be necessary to keep track of individual well performance by periodic testing.

Description of Central Battery

The battery was designed and constructed to be readily adapted for vapor collection. Vapor-handling equipment was not designed initially due to the lack of a close estimate of volumes to be handled. Calculations past the roughest estimates were practically impossible since all operating conditions would be changed. There were too many variables involved to make laboratory calculation feasible.

It was decided to use cone roofs with protective coating inside to resist corrosion. Floating roofs were not easily adaptable to vapor recovery. Also floating roofs might give a crude vapor pressure so high that the pipeline could not handle it.

The battery consists of four 20,000-bbl cone-roof tanks, each equipped with two 6-in. pressure-vacuum emergency vents weighted to open at 1.15 ounces pressure and 0.43 ounces vacuum. Blanket gas is taken from a plant residue line to separate pressure regulators for each tank. These regulators are of the large diaphragm type for sensitive operation. For blanketing, pressure is held at about ½ ounce.

For the convenience of producing personnel, tanks are equipped with ground level gaging and sampling devices. The pipeline requires, however, that for their purposes, gaging and sampling still be done through the deck. To maintain gas blanket pressure and not lose any vapors, gas-tight gaging and sampling heads are used so that these operations can be under pressure.

Fig. 1 shows schematically the normal production routine at the storage battery as it was operated initially. Alternately each tank is filled, weathered, run, and the bottom circulated. Production is continuous at the rate of 15,000 bbl per day. The greatest part of the vapor is from the tanks filling and weathering.

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Design of Recovery System

As soon as new facilities were in operation, measurement of vapor was begun in order to determine necessary line sizes and compressor capacity.

Testing program. The Devonian oil flows through emulsion treaters before going to storage. Gas from emulsion treaters as well as from the tanks would eventually reach the gasoline plant. It seemed logical to hold treater temperatures high to drive off most of the lighter ends where gathering and compression facilities already existed. Any liquid in the gathering system is discharged from the plant inlet scrubber to a slop oil tank and is charged back against lease allowable.

Maximum venting rate was 500 Mcf per day, while the greatest daily average rate was 430 Mcf per day at 146 F treater temperature. Average Reid vapor pressure in the tanks was about 10.3 psi. Tank vapors were sampled and analysis showed the content to increase from 14.8 gal per million (raw) to 19.72 gal per million as the tank was filled. Greatest venting rates occur at the lowest liquid levels when more complete flashing is occurring. Standing losses were estimated at about 10 percent of measured filling losses, using available published curves and nomographs on storage losses.

Vented gas was measured during filling with three 4-in. orifice well testers. These were installed in couplings welded in the plate of the tank deck. Gas was vented to atmosphere and pressure was taken on a low-pressure recorder. The pressure recorder was checked periodically against a water manometer to insure accurate chart interpretation.

Recovery Estimates

Expected additional plant recovery was estimated at $290 per day, based on a pessimistic 400 Mcf per day of vapor. This would be the net value of additional 12 psi gasoline, propane, butane, and residue gas. The estimate was based on gas analysis and plant recovery of all the gasoline and butane and 85 percent of the propane. Recovery equipment cost less than $40,000 with a payout of less than five months. Additional annual income would be over $100,000.

Description of the Installation

The installation was made as shown in Fig. 2 consisting of piping from each tank manifolded to a 15-in. by 9-in. single-stage, double-acting compressor, driven by a 50-hp electric motor. Suction is at slightly over atmospheric pressure and discharge is at 10 psig to an existing 6-in. gathering line 200 ft away. The compressor is equipped with a suction valve unloader on one end to compensate for low suction pressure when gas volumes decline during climatic effects on the tanks. There are also automatic shut-down controls in case of too low suction pressure or high liquid level in the scrubber.

In laying out piping and compressor controls, a decision had to be made on how to manifold the tank vapor lines for best gas richness and volume, as well as for continuous compressor operation. Original plans were to have individual pressure regulators on each tank vapor line. This would provide individual tank pressure control, but would leave little operating range for compressor controls. If all the tanks were manifolded with open lines, the system would be essentially a vapor balancing system with some of the rich vapors swapping tanks. Dry residue gas would pick up more evaporated ends than nearly saturated gas from another tank.

Comparisons were made of the volume of input blanket gas with the space voided when a tank was run. As illustrated in Fig. 3, the volume of blanket gas injected amounted to only 60 percent of the volume of oil run. The extra 40 percent, then, must have come from evaporation. To take advantage of this and still have simple compressor control, check plates were installed in the tank vapor lines to prevent vapor backflow. The check plates serve as check valves, yet they are inexpensive, light and have a light semi-balanced clapper. The clapper of the normal swing-check valve weighs about 30 lb and might

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have caused excessive pressure drop in the line.

Operation

Operating conditions. The compressor was started and vapors were placed "onstream" with very little difficulty. Compressor controls were set after a little experimenting within the narrow pressure ranges available. Blanket gas regulators were set to maintain a minimum of 0.3 in. of water pressure on the tanks. Both ends of the compressor cylinder take suction until suction pressure pulls down to 0.6 in. of water, at which time the intake valve on one end is pneumatically opened. The compressor then operates at about half the capacity until suction pressure builds back to 1.2 in., when it again starts compressing at both ends of the cylinder. If suction pressure declines to as low as 0.4 in. of water, the compressor stops until pressure builds back up. At 0.8 in. of water the compressor automatically starts again.

The vapor compressor inlet scrubber is accumulating about 100 gal of hydrocarbon liquid and 20 gal of water per day. This condenses out during the cool nights and part of the hydrocarbon liquid revaporizes during the day.

Recovery. Half a million cubic feet per day of rich gas is being delivered. It was difficult to determine exact plant additional recovery due to this new gas stream during the first few weeks of operation. Compressors were operating close to full capacity and plant processes were still being adjusted. Of course, there was a noticeable increase in plant liquids.

Fig. 4 is a graph of total plant liquid recovery, showing average daily recovery by months. Since the plant process was changed during this period (point "B") the plot of the low-pressure gas volumes at the plant is a little more indicative of the effect of treater preheating (point "A") and insulating (point "C"). This extra heat at the treaters became necessary to control stock tank vapor pressure during winter months. Tank vapors reached the plant beginning at point "D" in Fig. 4.

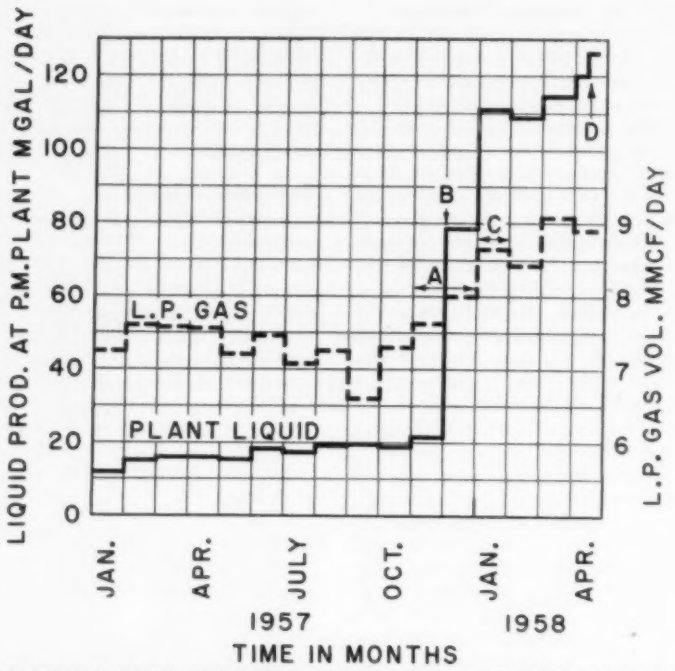
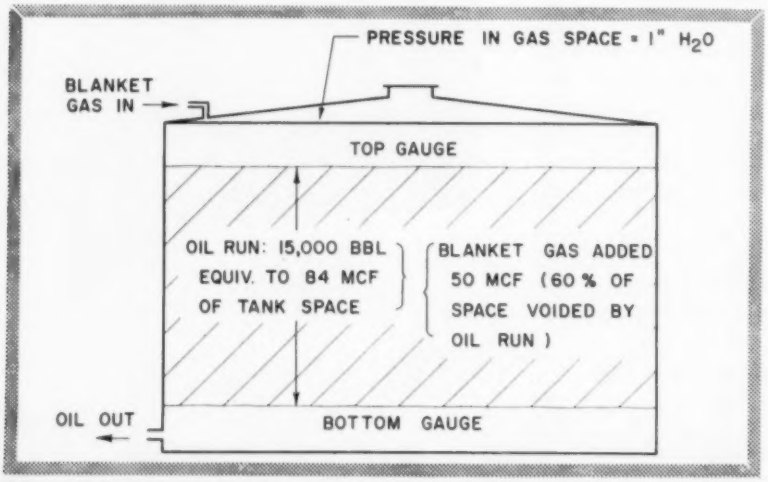


FIG. 4. **Graph of total plant liquid recovery.** Large increase in plant liquid at point "B" is indicative of effects of treater preheating ("A") and insulating ("C"). Tank vapors reached plant beginning at point "D."

With all the variables in the lease and gasoline plant operation, the truest indication of the effectiveness of work at the central battery will be to measure total vapors and gas richness at the vapor compressor discharge, just as was done in estimating for compressor and line sizing. Evaporation rates should stay fairly constant the year round as long as constant vapor pressure crude is maintained in the tanks. When adjustments are completed, total plant recovery should increase by approximately 10,000 gal per day.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BLANKET GAS ADDED 50 MCF (60 % OF SPACE VOIDED BY OIL RUN)
OIL OUT
BOTTOM GAUGE

FIG. 3. **Blanket gas requirement** amounts to 60 percent of the volume of oil run. Extra 40 percent comes from evaporation of lighter ends in the tank.

Conclusions

This project has proved that vapor recovery can be a profitable means of evaporation loss control. It has given new incentive and justification to centralizing storage facilities in other locations. More of this type work can probably be done with broader field-wide planning of lease producing facilities. Too, there are probably many smaller lease installations that could be adapted to vapor recovery work. Smaller, more economical compressors could be considered, and vapor evacuation by eductor tubes is another possibility if there is a source of gas that could be piped across the tops of the stock tanks.

Most producers would probably do well to review their storage losses and to make a closer analysis, comparing the economics of preventing evaporation against the processing of these escaping lighter ends.

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5. The Vapor Recovery Systems Company, *Varec Technical Bulletin CP-1001*, 6, 9 (1955).

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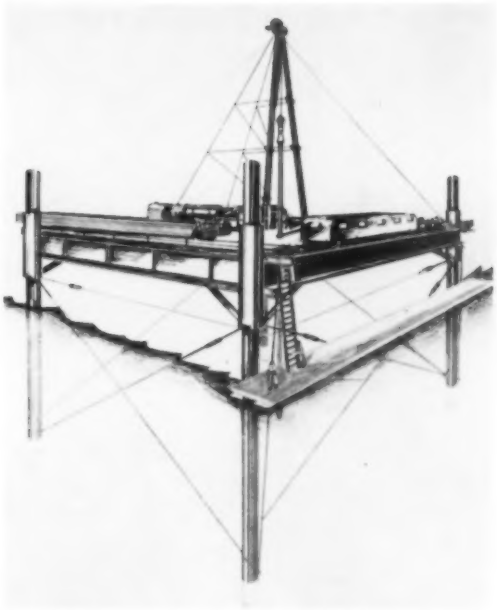
Rig will set its platform's legs; to test five known gas zones



Artist's concept of 50-ft square drilling platform shows it raised about 25 ft above the water with the cable tool rig in operation. After completion of a well, the tubular legs will be raised above the water level and the platform towed to the next site.

FIRST OFFSHORE drilling on the U. S. side of Lake Erie will soon get underway using a specially-made mobile platform. Drilling will be done using a cable tool drilling rig mounted on a 50 ft square platform.

New York State Natural Gas Corporation, the operator, will use the structure to drill for gas near the Pennsylvania-Ohio border.

Platform Assembly

The offshore drilling platform, constructed at Erie, Pennsylvania, was scheduled for completion April 30. About 50-ft square, the structure will consist of five pontoons pinned together and legs of tubular pipe at each corner. Each of the pontoons — actually watertight barge sections — is of welded steel and measures 50 ft long, 10 ft wide and 8 ft in depth. The legs are 36-in. in diameter and 130 ft long.

The legs will be dropped to the lake bottom after the platform is towed to its location. Two 100-ton hydraulic jacks at each of the four legs will raise the platform about 25-ft above the water. The cable tool rig will be rigged to drive the legs to a solid surface on the lake bottom.

New York State Natural engineers say that the type of structure chosen for the Lake Erie drilling has several advantages. Although it costs more to build than the stationary type used in many offshore operations, the small size and great mobility of the platform affords lower moving and relocation expenses that will pay off after several moves.

Contract Driller Gets Job

A cable tool drilling rig is to be used because regular rotary equipment would require a larger and more costly platform, the engineers said.

Drilling crews will go ashore as they complete their shifts. For emergencies, a trailer to accommodate six men with sleeping and eating facilities will be located on the platform. The actual drilling will be done by a contractor.

Drilling Site Chosen

The company expects the first well to develop in about 90 days. It will be located in Block No. 1, a 19,130-acre tract on the Pennsylvania border.

Operations will be administered out of Conneaut, a community in the northeast corner of Ohio near Block No. 1. Earl Altman, superintendent of New York Natural's central division, will be in charge.

Drilling in the lake must be done in the Lake Erie navigation season: About April 15 to November 15. Ice formations and cold winds prohibit operations in winter and early spring months.

No drilling is to be done closer than half a mile from shore, with 6½ miles the average maximum. Geologists anticipate finding gas in any of five formations: Oriskany, Lockport, Medina, Trenton, and Gatesburg. The Oriskany in the area lies at about 1500 ft and the Gatesburg at a depth of about 5780 ft. Known trends of gas and oil production lie in northeast Ohio and extend into Canada and New York. Drilling in Lake Erie is expected to tap these trends, according to the company.

Long Range Program

New York Natural also plans to drill in a second area in the lake in the future. This is known as the Block No. 2 area and consists of 16,580 acres near the Pennsylvania-New York border.

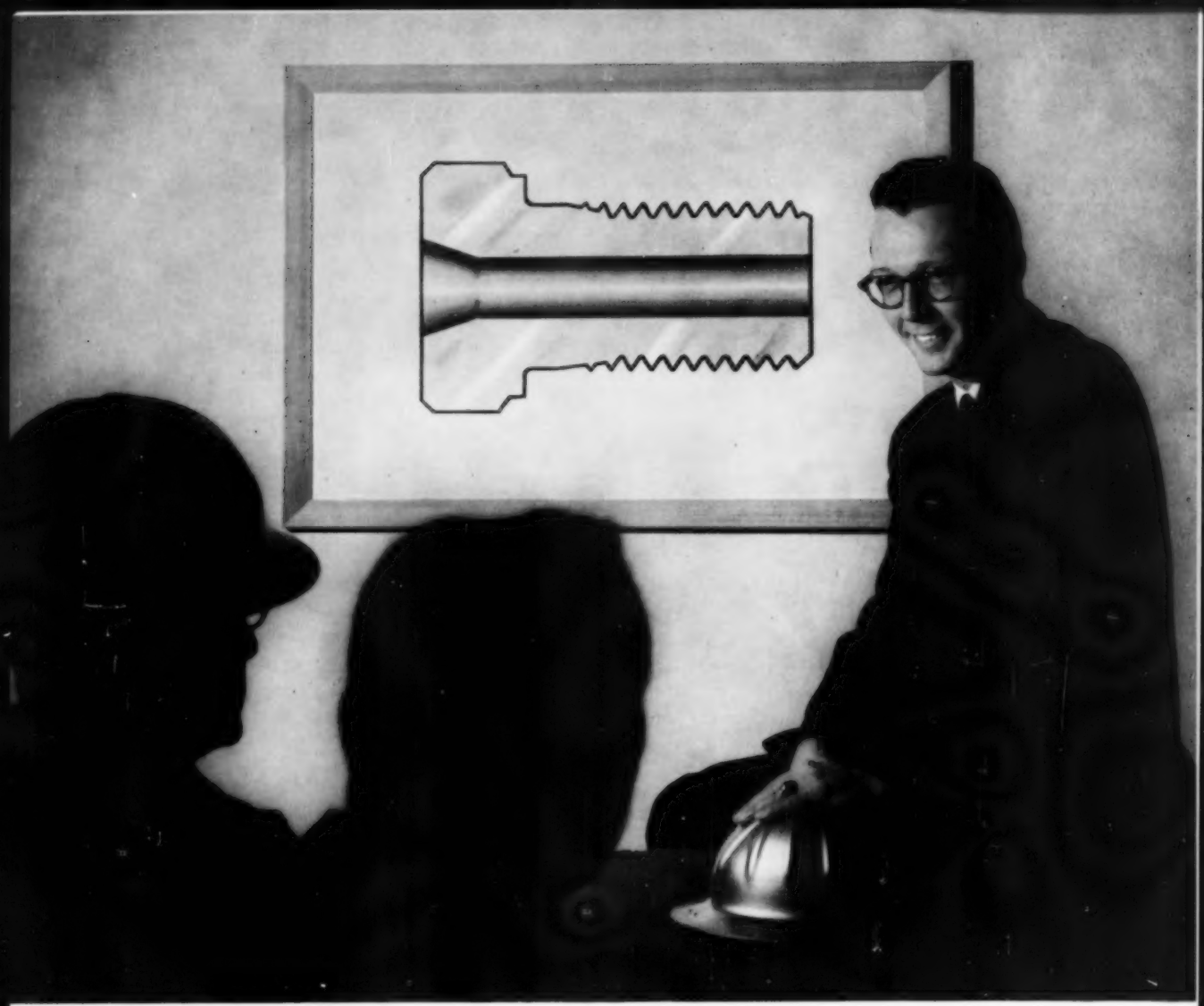
Both tracts of Lake Erie acreage have been leased from Pennsylvania's Department of Forests and Waters. In addition to a $90,917 annual rental fee, New York Natural will pay the state a royalty on gas or oil discovered in the tracts.

Underwater Completion

Company officials have been instructed to complete wells on the lake bottom. The cellar, master gate, Christmas tree and flow lines must be installed on the lake floor by divers.

Existing Wells in Canada

Although New York State Natural Gas will be the first firm to drill offshore on the U. S. side of the lake, drilling on the Canadian side dates back to 1913 when gas was found 300 ft offshore. At last count, in October 1957, 78 wells had been drilled in Lake Erie on the Canadian side. ★ ★ ★



THIS IS ONE WAY TO SAVE MONEY ON PRODUCTION COSTS

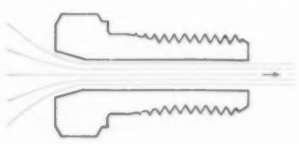
Cameron's Bob Le Rouax, Senior Engineer, Answers Questions About the New "Honest John" Choke Bean.

MR. LE ROUAX:
The new Cameron "Honest John" bean holds metering accuracy much longer than conventional beans. This means fewer changes and greater economy.

QUESTION:
How does this new "Honest John" bean differ from old style beans?

MR. LE ROUAX:
The tapered entrance in the "Honest John" produces a flow pattern which does not buck abrasives with a sharp edge as in conventional beans.

QUESTION:
Isn't a sharp edge on the bean necessary for metering accuracy?



MR. LE ROUAX:
No. There are many ways to get accuracy. For a bean with a sharp edged entry, of course, a sharp edge is essential; however, on most wells the edge erodes quickly, and the bean loses its accuracy. Cameron spent two years developing and testing the "Honest John." The result is an orifice design which is accurate, but more important, it retains its accuracy much longer than conventional beans.

QUESTION:
What are these new beans made of?

MR. LE ROUAX:
They are available in alloy or stainless steel. These fine grain steels are made in our own melt

shop by the most modern methods. With closely controlled heat treating they become extremely hard and tough.

QUESTION:

Do sizes compare with old style beans?

MR. LE ROUAX:

No. There are several differences. Size for size the "Honest John" produces 10% to 12% more fluid than conventional beans. In the smaller sizes, from 2/64 to 12/64, each diameter increase gives a 15% flow increase over the preceding size. This means lower field inventories and greater flexibility in range. The maximum "Honest John" bore diameter is 40/64—almost three times as much flow capacity as conventional insert type beans. The generous cross section eliminates the "Dutchman" problem.

QUESTION:

How much instruction will I need to change from the old system?

MR. LE ROUAX:

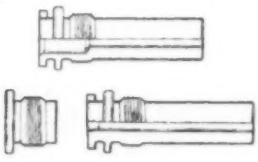
None. As an aid, Cameron has available for the asking slide rules and nomographs for selecting bean size where oil and gas ratio and tubing head pressures are known. We believe that any one actively engaged in production control will welcome the reduced effort, the convenience and economy of this new development.

QUESTION:

Sounds great, but several of my trees are not Cameron products? What about these?

MR. LE ROUAX:

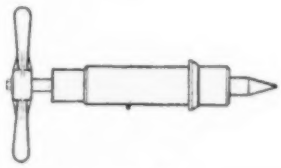
I'm glad you mentioned that because the "Honest John" along with our stainless steel adapters will fit almost any set-up in use today



Now a description of other components in our coordinated production control equipment group. In addition to the "Honest John" bean, Cameron has also developed the "Big John," a six inch bean, with the same basic design refinements. The "Big John" fits Cameron "H2" Chokes and Cameron Flow Controllers.

The "Big John" combination bean and seat is a needle valve seat and positive choke which saves time and money on wells when its use is desired.

As mentioned earlier, the new Bean Adapters permit use of the "Honest John" with existing Cameron equipment as well as most competitive equipment. Their careful manufacture from corrosion-resistant stainless steel insures years of trouble-free performance.

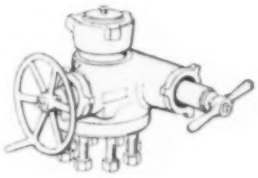


Cameron's new "H2" adjustable choke features a pre-loaded packing design which greatly increases the life of the packing, protects the needle threads from contamination, corrosion and galling, and makes the choke considerably easier to operate.

The "H2" adjustable choke needles and seats are furnished in stainless steel as standard equipment. Hardfaced needles and seats are also available on request.

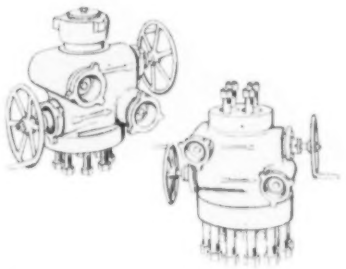
An "H2" adjustable choke can be converted to a positive choke by removing the adjustable seat and choke bonnet and substituting a "BJ" bean or "HJ" bean and adapter and a blanking plug.

In addition to the versatile Type "H2" production choke, Cameron is now offering new single, double, and dual flow controllers. These flow controllers feature a new pressure-balanced valve with a cast Stellite® alloy seat. Instead of simply hardfacing the seat, the seat ring is cast, precision ground and polished. This procedure insures a homogeneous material at the point of contact and positively does away with leaks. The seat and gate engage directly. Wear caused by the grinding effect of rotating engagements is eliminated.



For easy operation the stem is fitted with bearings which may be quickly replaced in the field. Packing in the "HJ" valve is adjustable.

In closely controlled laboratory tests drilling mud with 5% sand was circulated through these "HJ" valves at 150 psi flowing pressure and 1000 psi closed in pressure. The valves were opened and closed 1000 times. Pressures were then elevated to 10,000 psi without a single valve failure.



Cameron "HJ" Flow Control Valves may also be installed in "HD" flow control bodies and "H" choke bodies.

Our goal has always been increased safety, convenience and economy for the users of Cameron equipment. Today more than ever we are happy to help producers everywhere cut costs with these new designs.

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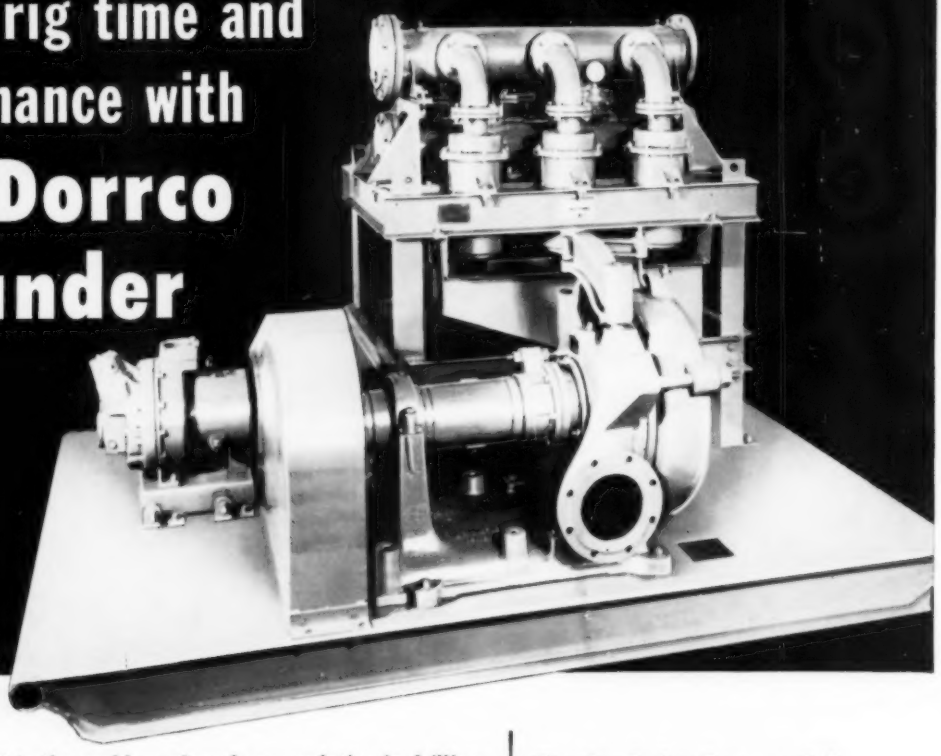
RIG OPERATORS...

reduce rig time and maintenance with The Dorrco D-Sander



The best answer yet to the problem of sand accumulation in drilling muds, the Dorrco D-Sander provides a means for continuous removal of abrasives, returning to the mud pump a low-solids mud containing less than 0.2% API sands.

To the rig operator . . . this may readily be interpreted in big dollar savings on . . .

Surface equipment — slush-pump maintenance costs are drastically reduced . . . tank cleaning for removal of sands and solids is practically eliminated.

Bit performance — is extended considerably with a corresponding reduction in the number of round trips, longer R.O.B.

Actual rig cost savings shown are drawn from a Gulf Coast operation, figures are based on six comparative wells in same field.

Typical Savings with D-Sander 0-9500 Ft.

Actual rig time saved

rotating.....45 hrs.	
round trips..... 8	
downtime cleaning tanks.. 4	
57 hrs. at $62.50	**$3,562.50**

Actual equipment savings

2-9⅞" bits at $250.00.....	$500.00
Mud pump parts.....	1,400.00
Surface mud equip. (est.).....	250.00
Total Savings per well	**$5,712.50**

For more information on the Dorrco D-Sander contact our U. S. Sales Representative, Salt Water Control Inc., 1211 Fort Worth National Bank Building, Fort Worth 2, Texas.

D-Sander T.M. Reg. U.S. Pat. Off.

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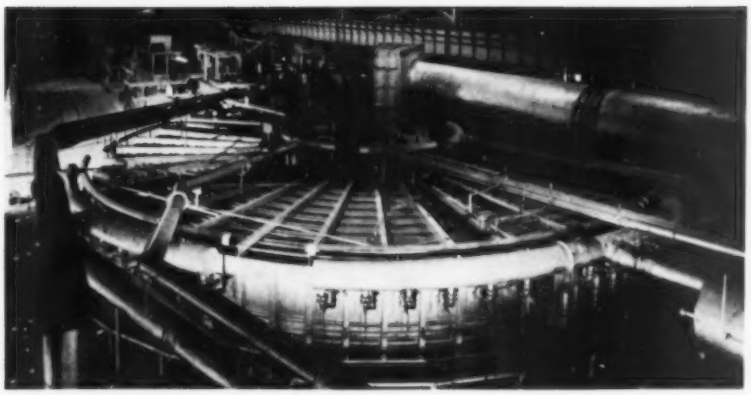
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



Rotary furnace, with the largest hearth of its type in the world, is the initial manufacturing process in the new Number Three Seamless Pipe Mill at the Indiana Harbor Works of The Youngstown Sheet and Tube Company. The furnace is designed to heat 190 steel billets per hour.

Push Button Pipe Mill Unveiled by Youngstown

Youngstown Sheet and Tube Company has unveiled its new Number Three Seamless Pipe Mill at the Indiana Harbor Works, East Chicago, Indiana. The new mill is streamlined for the most modern pushbutton operation and is designed to produce pipe varying from 4½ to 9⅝-in. OD, primarily for oil country use.

One of the outstanding features of the new mill is a mammoth rotary furnace, said to have the largest hearth of any of its type in the world.

The rotary hearth furnace is designed to heat 190 steel billets per hour. It has six heating zones at a maximum of 2250 F. Its capacity is 100 tons per hour.

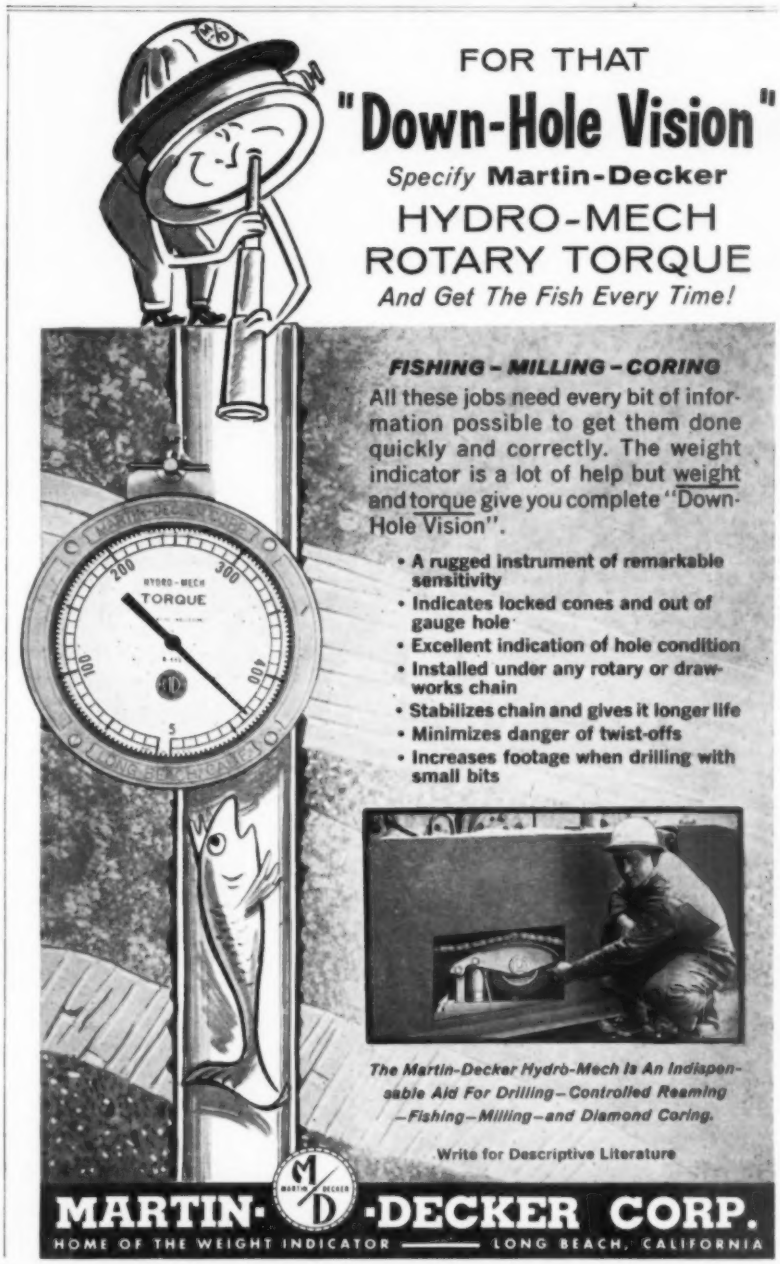
The new seamless pipe mill is housed in a two-part building that totals over 4000 ft in length.

Seamless steel pipe is manufactured by a process that involves putting a hole down the center of solid steel "rounds."

The operation at Youngstown's new plant is performed almost automatically from the time the cold steel billets enter the rotary furnace until the finished pipe rolls from the plant threaded, measured, stenciled, painted and weighed.

This is the company's first seamless installation for its Chicago district. Until this mill was put into operation, all the company's seamless products were made at Youngstown, Ohio. Construction was started in 1955 in an area that was once a part of Lake Michigan. For this reason, all buildings in the reclaimed area rest on foundations supported by steel pilings driven more than 100 ft down to bedrock.

The seamless mill was completed and put into operation a few months ago. Steel used in the plant for making the tubular goods are from bars poured at the Harbor Works and shaped in the plant's merchant mills.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"Down-Hole Vision"
Specify Martin-Decker
HYDRO-MECH
ROTARY TORQUE
And Get The Fish Every Time!
FISHING – MILLING – CORING
All these jobs need every bit of information possible to get them done quickly and correctly. The weight indicator is a lot of help but weight and torque give you complete "Down-Hole Vision".
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HOME OF THE WEIGHT INDICATOR — LONG BEACH, CALIFORNIA

EXPLORATION ACTIVITIES

TEXAS

Domal Discoveries Spur New Activity

Thickest Pay in East Texas

The Texas Company's significant Woodbine sand discovery has been completed for a daily initial potential flow of 141 bbl of oil. The well, the No. 1 Arthur Rabe, was completed at 5660-70 ft. It is located on the Oakwood Dome, two miles north of Keechi in southeast Freestone County, and was begun as a geological wildcat.

The discovery is credited with 246 ft of net pay, the thickest found in East Texas. It is 10 miles from the Long Lake field. It is located on the Oakwood high. Texaco drilled through some 4400 ft of salt, topped at approximately 1100 ft. Solid gas pay 83 ft in depth was logged between 5501-99 ft. This was followed by 116 ft of oil sand from 5599 to 5737 ft.

First Wolfcamp Oil In Goldsmith Area

A significant Wolfcamp discovery in Ector County was reported by Cities Service at its Cummins D No. 8 well in the Goldsmith area. On drillstem test of the Wolfcamp between 7230 and 7296 ft, the well flowed 63 bbl of oil in two hours. Test was through a 1-in. choke, the flowing surface pressure was 78 psi and the gas-oil ratio 1650 to 1. This is the first Wolfcamp production in the area.

In addition to regular pays in the upper and middle Clearfork, a lower Clearfork pay was indicated. This lower pay is not present in the area. Cities Service holds a 96.13 percent interest in the discovery, with other interest held by Pan American Petroleum Corporation.

First Gas for Pescadito Dome

Ginther, Warren & Ginther, operator for a GW&G-Gulf Oil-Mike Halbouty joint venture, the No. 1-B O. W. Killam, has found first commercial gas production on the large Pescadito Dome in Webb County. The well is 14 miles northeast of Laredo. The rank wildcat was completed in the Wilcox for an absolute open flow of 9,100,000 cu ft of gas per day, plus 35.3 bbl of 55 deg condensate per MMcf. On 12/64-in. choke the flow was 1,500,000 cut ft per day. Shutin tubing pressure was 2350 psi. Completion was at 6000-38 ft; total depth of the well was logged at 8577 ft.

The group's No. 1-A Killam is drilling in sidetrack hole at 11,900 ft around a section of hole plugged with stuck drill pipe. This well was drilling at 14,004 ft when a blowout occurred and drill pipe was lost. Attempt will be made to re-enter original hole at about 13,800 ft, and is scheduled to go to 16,500 ft or to the Edwards lime. The 1-A Killam is about ½ mile east of the discovery well.

GW&G's No. 1 Killam was abandoned because of extreme bottomhole temperature a few months ago. This well recorded a temperature of 460 F at a total depth of 15,107 ft.—*(The Petroleum Engineer,* October 1957, page B-21.)

PERU

20 Wells for Talara Region

Amotape Oil Company, with David M. Grubbs of Dallas and a group of Texas oil men, has announced plans to drill 20 oil wells in Peru. Panatex Drilling Company, with Grubbs as president, has been formed to handle the operations.

Material for the first four wells is enroute to Talara, Peru. Amotape's 100,000-acre properties are located along the Pacific shoreline 40 miles northwest of Talara. They adjoin the Lobitos-El Alto fields of International Petroleum Company and Petrolera Lobitos and are adjacent to the area held under similar contract by Peruvian Petroleum Company, owned by Cities Service Company and Richfield Corporation. Amotape, a United States corporation, presently operates four producing wells through its subsidiary, Petrolera Amotape S.A. of Lima, Peru.

AUSTRALIA

Delhi-Taylor Tries 'Down Under'

Exploration work is to begin this summer in a new attempt to find oil in Australia. Delhi-Taylor Oil Corporation of Dallas, Texas, has formed a subsidiary to handle operations now scheduled as a result of a newly-signed agreement. The company, Delhi Australian Petroleum Ltd., is entering into the work with Santos Ltd., an Australian organization which holds exploration licenses on 267,000 sq miles in the states of Queensland and South Australia. Delhi has agreed to make geological and geophysical studies and is to drill at least one stratigraphic test. This will earn the company a half interest on the acreage on a checkerboard pattern basis.

DELHI-TAYLOR'S AUSTRALIAN PROSPECT

CALIFORNIA

New Pay at New Ventura

Continental Oil Company has found a new and deeper producing structure on its prolific 2542-acre Grubb lease in New Ventura. The discovery well, No. 39-2, flowed 570 bbl of oil through a ¾-in. choke on a 24-hr test at a total depth of 11,050 ft.

The lease, about five miles northwest of Ventura, also contains the company's San Miguelito oil field. It is one of California's most productive leases, having netted over 47,000,000 bbl of oil since discovered by Continental in 1931. Previous production in the field has been from 8000 to 9000 ft.

KANSAS

Sherman County Well Is 'Talk of the State'

Phillips Petroleum Company has what appears to be an important oil discovery in a well drilled in the middle of a 22,380 net acre block in Sherman County, northwest Kansas. The discovery appears to open a new oil province approximately 31 miles from the nearest production.

The well is a stratigraphic test on one of a number of large well-located blocks which are part of approximately 1,000,000 acres Phillips holds in the Las Animas Arch area. Sizable amounts of oil were recovered on five drillstem tests between 4458-4833 ft in three different formations. Drilling is continuing.

The well is approximately 15 miles northeast of Goodland, Kansas, in NW NE, Sec. 10-6s-37w.

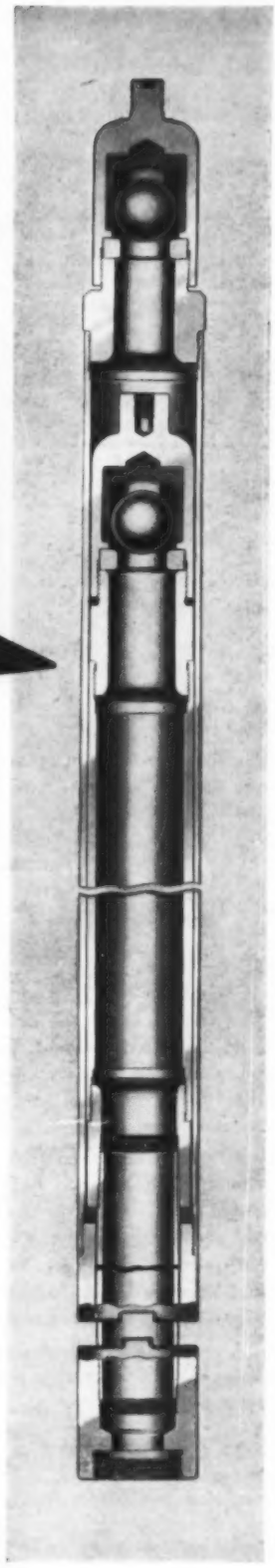
Haskell 'Cat Gages Big Flow

White Eagle Oil Company has reported the results of the official potential test for its rank wildcat discovery well, the No. 1 Eubank, located in the NW/4 NW/4 of Section 28, T 28 S, R 34 W, Haskell County. The well flowed at the rate of 502 bbl of oil per day through a ½-in. choke from perforations in the Chester sand at 5439-45 ft. Total depth of the well was 5692 ft.

The new discovery, located on a block in which White Eagle has 1440 net acres, lies about 8 miles south of the Pleasant Prairie pool in Finney County, Kansas. In this area White Eagle has drilled 15 oil wells and no dry holes over a five-mile span wholly contained within the company's 25,000-acre block. White Eagle's oil production in the Pleasant Prairie area is from the Mississippian at about 5100 ft and underlies gas production in the Hugoton field.

*Designed for Your Waterflood**

*WITH THIS PACIFIC INSERT ROD PLUNGER PUMP YOU GET VOLUME *plus*



1 A precision insert rod pump of 4½" O.D. x 3¾" I.D. built to Pacific standards.

2 A specifically designed pump for pumping large volumes of fluid efficiently **at any speed**—fast or slow—with a conventional pumping unit installation.

3 A pump that will seat in a regular production casing packer and may be operated in 5" casing (or larger) thereby eliminating tubing.

4 A pump ideally suited for pumping water supply wells in the range of 2000 to 3000 barrels of fluid per day for water flooding operations.

5 A pump equipped with Pacific Pacilite chrome plungers and the latest design rubber lined cages for long trouble-free operation.

Ask your Pacific field salesman for more details or write:

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Exploration

LIBYA

Oasis Starts First Well

Oasis Oil Company of Libya, a wholly owned subsidiary of the Ohio Oil Company, is drilling below 2500 ft in its first exploratory well in the north African country.

Oasis Oil is the operating company for Libyan concessions totaling nearly 62,000,000 acres. Ohio Oil, Continental Oil, and Amerada Petroleum hold undivided one-third interests in these concessions.

Seventy-five miles south of the Gulf of Sirte, the well, No. 1 Bahi, is drilling on concession No. 32. The wildcat will test a long north-south trending anticline mapped by Oasis Oil geologists. A seismograph survey confirmed the surface work.

TURKEY

Bolsa Chica Begins Tests

The first of seven or eight wells to be drilled by Bolsa Chica Oil Corporation in Turkey is getting underway on the company's 370,000-acre block. Bolsa Chica, a Los Angeles based organization plans to drill the series of exploratory tests over a period of 2½ years. First well was expected to be spudded about June 1. Bolsa Chica has a third interest in the operation.

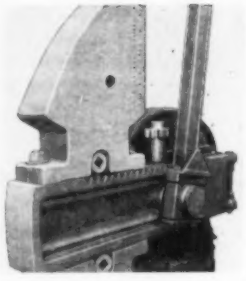
The NEW JENSEN ROTARY BALANCED JACK

It's the **NEW,** all-new **ROTARY SERIES** of full crank balanced pumping jacks now offered by **JENSEN** in addition to their famous Standard Series.

All cranks and weights are floor clearing, permitting installation on flat concrete surfaces or simple steel skids. Expensive special foundations and crank weight wells are eliminated.

These new **JENSEN ROTARY BALANCED JACKS** have larger and heavier main shafts and bearings, and taller sampson posts.

A new catalog fully describing this new Rotary Series is just off the press. A call or letter will bring **your copy** quick!



The rack-and-pinion system on the new Jensen Rotary Balanced Jack makes weight adjustment a safe and simple operation for one man standing on the ground.

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Export Office: 250 Park Avenue, New York City

JENSEN JACKS

UTAH

Three States Perks Aneth Interest

Renewed interest on the western end of the Aneth field is seen following a significant completion by Three States Natural Gas Company. The company pumped 1437 bbl of oil per day from its No. 8 Arrowhead, located in SW SW of 14-41s-23e. Oil came from perforations at 5680-702 ft. Although Three States has several producing wells on its Arrowhead unit classified as direct offsets, the No. 8 suggests a westerly extension. An El Dorado Refining Company dry hole in NE SE of Section 15 has until now slowed interest in the area lying between Aneth and Bluff pools.

OKLAHOMA

Panhandle Gets New Gasser

Petroleum Inc. has finaled a rank Texas County wildcat as a commercial gas well. The operator is still drilling ahead after indicating commercial gas in the Morrow at its No. 1 Denning. The well, in C SE NW, 30-6n-11e, is six miles east of the Northwest Carthage pool. The well gaged 2,420,000 cu ft of gas per day and recovered some condensate on a one-hour drill-stem test at 4518-28 ft. Well is to be drilled to 5200 ft.

PARAGUAY

Pure to Begin Chaco Well — With New Partners

Pure Oil Company of Paraguay, Inc. is sharing its 23,400 sq mile oil exploration concession in the Chaco territory of northern Paraguay with Paraguay Gulf Oil Company, Sinclair Paraguayan Oil Company, and Tidewater Oil Company. Williams Brothers Corporation, an international contractor, was Pure's original partner in the concession which was awarded by the Paraguayan government last October.

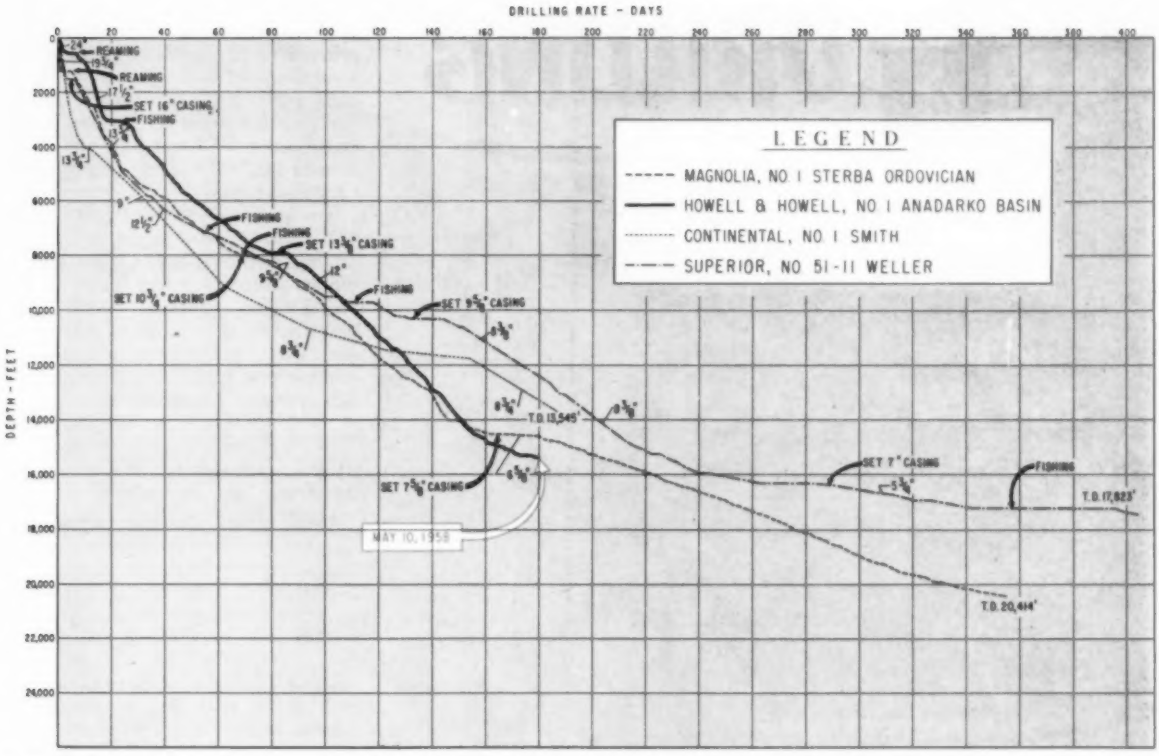
Under the new arrangement Pure Oil Company of Paraguay, Inc. will be the operator and retain a 30 percent interest. Paraguay Gulf Oil Company has acquired a 25 percent interest from Pure Oil Company of Paraguay, Inc. Sinclair Paraguayan Oil Company and Tidewater Oil Company have acquired interests of 15 and 10 percent, respectively, from Williams Brothers Corporation which retains ownership of 20 percent.

Drilling operations are expected to be commenced in early June, it was announced by the operating company.

To reach the first drill site, a 120-mile dirt road must be built. Sixty miles have already been completed. The road runs north from the terminus of a narrow gage railroad 70 miles west of Puerto Casado on the Paraguay River.

PROGRESS REPORT NO. 3

Anadarko Basin No. 1
Caddo County, Oklahoma



Drilling rate curves show the progress of Howell & Howell's Anadarko Basin No. 1 and three other deep wells drilled in the same general area. On May 10, the deep-test well was drilling in hard sand at a depth of 15,486 ft, 181 days after spud date.

HARD SAND SLOWS OKLAHOMA DEEP TEST

HARD SAND has slowed down drilling progress at Howell & Howell's Anadarko Basin No. 1, the Caddo County, Oklahoma well planned to drill to 24,000 ft. *(The Petroleum Engineer*, March 1958, page B-31.) Drilling during the 30 days from April 10 to May 10 averaged 47.8 ft per day, dropping from an average of nearly 100 ft per day registered during the preceding 31-day period.

Hole Record

This well was spudded on November 10, 1957, drilling a 24-in. hole to 540 ft which was cased with a string of 20-in. OD, 72.16 lb-per-ft line pipe cemented to the surface. A 17½-in. hole was then drilled to 7903 ft and cased with a special string of 13⅜-in. OD, N-80, 85 lb-per-ft casing. Drilling has continued with 12-in. hole tentatively scheduled to 19,000 ft. On May 10, bit No. 134 was run in the hole to continue drilling at 15,486 ft.

Gas Handling

Several gas zones have been drilled during the past two months and considerable volumes of gas are being produced. Rather than weight up the drilling mud to stop the flow of gas, Howell & Howell has elected to handle the gas at the surface, thereby lessening the danger of lost mud circulation due to using a heavier mud. However, mud weight has been increased during the past month from 11 to almost 12 lb per gal. Mud returns were lost momentarily when mud weight was increased to 12.2 lb per gal.

Mud Program

The driller's report dated May 10 showed the following mud characteristics: Weight, 11.8 lb per gal; viscosity, 64 seconds; oil content, 11.5 percent; solids content, 14 percent; chlorides, 3600 ppm. Chloride content has increased appreciably during the few preceding days.

The two 18-in. stroke mud pumps are pumping with 5¾-in. liners at approximately 2000 psi. Circulation rate of around 620 gal per min is being maintained with 50 strokes per min. Weight on the bit in the hard sand is approximately 75,000 lb.

In accordance with plans to drill with a telescoping string, several stands of 4½-in. drill pipe have been picked up along with the string of 5½-in. pipe. As hole is drilled deeper, the drill string will consist of 4½-in., 5-in., and 5½-in. pipe. ★ ★ ★

What's doing in DRILLING

"Seadrill No. 2" Joins Offshore Fleet

American Marine Corporation of New Orleans has announced the completion and acceptance of another offshore oil drilling barge, the "Seadrill No. 2." The 180-ft barge is the second built by AMC for Sea Drilling Corporation, New Orleans. Main power plant of the new barge consists of three 900-hp diesel engines driving three 1200-kw generators.

Mud Prices Cut By Manufacturers

Magnet Cove Barium Corporation and Baroid Division of National Lead Company have announced price cuts of 12 percent and 8 percent on drilling muds. A spokesman for Baroid said the price cut of 12 percent on heavier muds would amount to "an estimated average of $6 a ton," while the 8 percent reduction on other chemical products would equal between $4 and $5 a ton. Magcobar pared its prices a like amount, an official noted.

The Baroid spokesman commented, "we know that the domestic oil well drilling industry is having a rough time. We are suffering in like manner." But the company hopes to maintain the lower prices as a result of economies and expects that the cuts will help the drilling cost picture and eventually benefit the mud company.

Hughes Tool Cuts Bit Prices 15 Percent

Further good news came to the drilling industry in the form of an announcement by Hughes Tool Company that prices of rock bits manufactured by the company have been reduced 15 percent.

M. E. Montrose, vice president-sales, said the across-the-board reduction applies to all rock bits distributed by Hughes in the U. S. and Canada. He said the reduction is an attempt by Hughes to aid the drilling industry and to stimulate the overall economy. Montrose hastened to add that the price cut will not affect Hughes' research and engineering programs, which are being expanded.

Smith Oil Tool Sets New Bit Marketing Policy

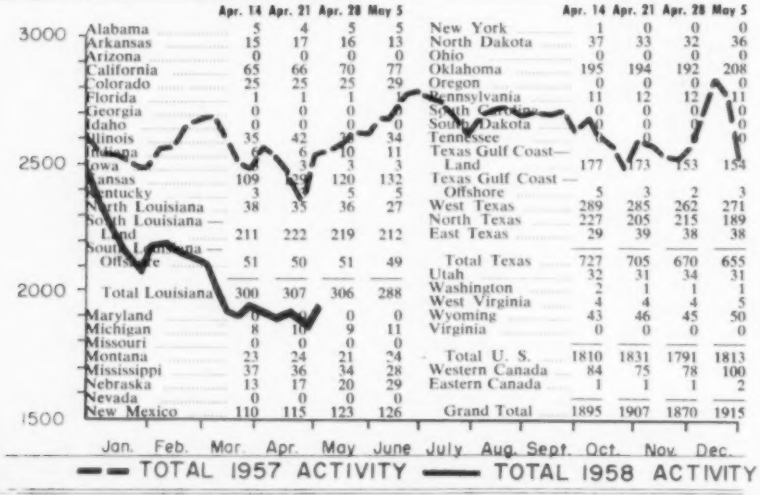
H. C. Smith Oil Tool Company customers will be invoiced direct under a major marketing policy change inaugurated by the company described as "a sales policy consistent with the way we distribute and service our rock bits" by Arthur S. Marshall, vice president — sales. Under the new policy, invoices paid by customers on or before the 15th of the month following the month of billing will receive a 10 percent trade discount off the list price and a 2 percent cash discount off the net price.

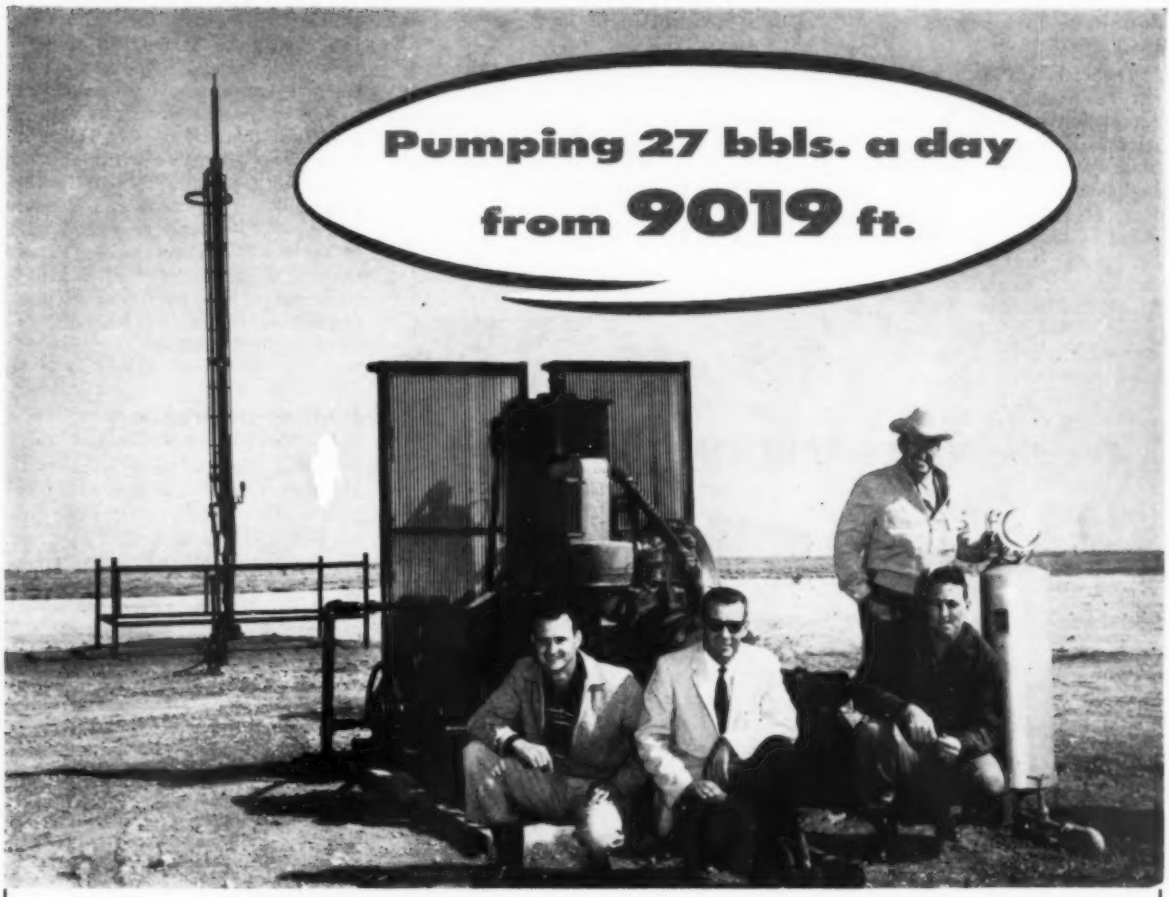
The practice of leasing direct to the customer, by-passing equipment supply houses, began on the West Coast and has spread eastward. Although other major bit manufacturers have made no official announcements of like policy changes, at least one bit maker has informed contractors that it will meet the terms granted by its competitors.

Rotary Rigs Operating in Oil Fields of United States and Canada

As reported to American Association of Oilwell Drilling Contractors by Hughes Tool Company.

	Apr. 14	Apr. 21	Apr. 28	May 5
Alabama	5	4	5	5
Arkansas	15	17	16	13
Arizona	0	0	0	0
California	65	66	70	77
Colorado	25	25	25	29
Florida	1	1	1	1
Georgia	0	0	0	0
Idaho	0	0	0	0
Illinois	35	42	34	34
Indiana	6	6	10	11
Iowa	3	3	3	3
Kansas	109	99	120	132
Kentucky	3	3	5	5
North Louisiana	38	35	36	27
South Louisiana — Land	211	222	219	212
South Louisiana — Offshore	51	50	51	49
Total Louisiana	300	307	306	288
Maryland	0	0	0	0
Michigan	8	10	9	11
Missouri	0	0	0	0
Montana	23	24	21	24
Mississippi	37	36	34	28
Nebraska	13	17	20	29
Nevada	0	0	0	0
New Mexico	110	115	123	126
New York	1	0	0	0
North Dakota	37	33	32	36
Ohio	0	0	0	0
Oklahoma	195	194	192	208
Oregon	0	0	0	0
Pennsylvania	11	12	12	11
South Carolina	0	0	0	0
South Dakota	0	0	0	0
Tennessee	1	0	1	0
Texas Gulf Coast — Land	177	173	153	154
Texas Gulf Coast — Offshore	5	3	2	3
West Texas	289	285	262	271
North Texas	227	205	215	189
East Texas	29	39	38	38
Total Texas	727	705	670	655
Utah	32	31	34	31
Washington	2	1	1	1
West Virginia	4	4	4	5
Wyoming	43	46	45	50
Virginia	0	0	0	0
Total U. S.	1810	1831	1791	1813
Western Canada	84	75	78	100
Eastern Canada	1	1	1	2
Grand Total	1895	1907	1870	1915





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Japanese Prepare to Drill Offshore

The waters off Japan will become the site of marine oil exploration after completion of plans by Japan Petroleum Exploration Company, Ltd., to build the country's first offshore drilling platform. And R. G. LeTourneau, Inc., of Longview, Texas, has been asked by "Japex" to supply "component parts and technical guidance" needed to construct the platform. A $1,500,000 contract between the two parties calls for LeTourneau to provide complicated ingredients and technical know-how for the platform which will be constructed in Japanese yards at Akita.

Current planning calls for completing the platform and beginning the first drilling operation within the coming year. It is believed that the initial hole will be drilled in the Sea of Japan about one mile off the northwest coast of the main Nipponese island.

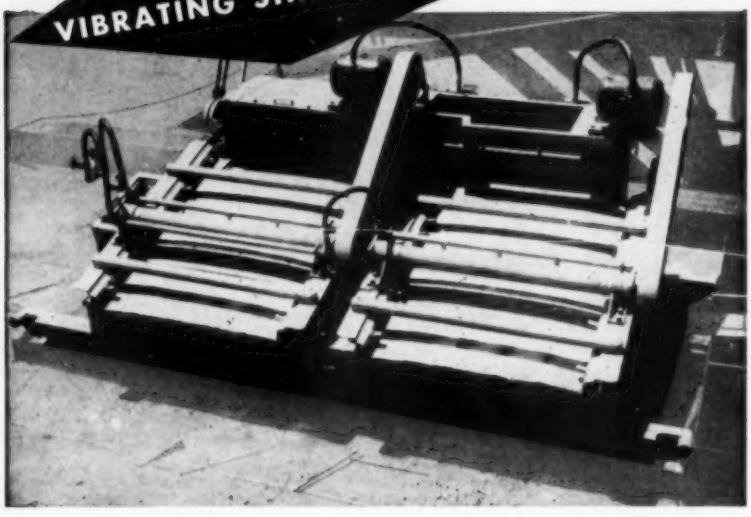
Drilling Contractors Set Date

Arrangements formulated nearly two years ago are bearing fruit as the AAODC officially set the date of its 18th Annual Meeting for October 1-3, 1958. The place: Dallas, Texas.

E. Dale Mount, chairman of the General Arrangements Committee and past AAODC president, met with his group for the first time in Dallas on April 21 to get the show on the road. Preliminary plans were laid for appropriate meeting events and attention was given to general program topics. M. G. Rowe, vice president for Rowan Drilling Company of Fort Worth, is chairman of the important Program Committee. The banquet will be held in the Adolphus Hotel.

For the VINEGARROON They Chose a

Thompson
VIBRATING SHALE SHAKER



Thompson . . . Perfect for Offshore Work!

On offshore rigs the reclamation of mud is vitally important and the separation of shale and abrasives from drilling muds means a more effective, time and money saving drilling job. Barnwell Offshore, Inc. chose Thompson for their new offshore rig, the VINEGARROON, because it was field proven, will give them clean mud and make tools last longer, with a minimum of re-tooling and restoration of mud solution.

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Methods Outlined to Meet Cost-Price Squeeze

During the 16 years since 1941, average rotary drilling costs have more than doubled at the same time that drilling prices have gone down 10 percent. So stated Walter H. Helmerich, III, of Helmerich & Payne, Inc., Tulsa, Oklahoma, in a talk before a group session at the Mid-Continent district meeting of the API, division of production. Helmerich asserted that there are three ways in which the contractor can meet this problem:

1. First, he can do a more efficient job of drilling—and he has. Since 1941, average drilling time has dropped 45 percent, but is still about 20 percent short to restore parity between costs and prices existing 16 years ago.
2. The contractor can work on boosting his prices, set by competition which is now at a fever pitch.
3. He must concentrate on the cost side of his books to know and control the ways money is spent.

Helmerich said that facts prove that the drilling contractor has not had a fair return on his invested capital during recent years and that his profit has not been adequate to maintain, to build, or to expand his services.

Canadian Crews Receive Safety Awards

At a recent meeting in Red Deer, Alberta, the crews of two drilling rigs of General Petroleums of Canada Limited were honored for having completed one year of intensive drilling activity without incurring a single lost time accident. General Petroleums' Rig No. 3 crew operated 261 days throughout the year drilling 85,570 ft of hole at 14 different locations and Rig No. 6 crew operated 255 days drilling 80,036 ft of hole at 15 different locations. Each of the rigs was presented with a plaque from the Canadian Association of Oilwell Drilling Contractors and the toolpushers and drillers were presented with certificates in recognition of this achievement.

Giant California Drilling Platform to be Spotted

The giant drilling platform which Standard Oil Company of California, Western Operations, Inc., and Humble Oil and Refining Company will use to test their state offshore oil lease near Summerland, California, will be floated to its site about June 10. The platform, consisting of a deck 110 ft square mounted on a tower 75 ft square and 170 ft high, is presently under construction at National Steel and Shipbuilding Company of San Diego.

Under tow, the tower will be floated on four caissons, each about 27 ft in diameter and 40 ft high, which also will serve as a permanent foundation for the four legs of the platform. Caissons will be anchored in place by filling them with 6000 tons of sand and concrete ballast. The platform has been designed to drill up to 25 wells from the same site, two at a time.

Tower for the offshore platform Standard Oil Company of California and Humble Oil & Refining Company will use to explore and develop their Summerland state lease rises under construction at National Steel and Shipbuilding Company, San Diego.

Phillips Sets New Texas Depth Record

A new record depth hole has been drilled in West Texas at the Phillips Petroleum Company No. 1-EE University, nine miles southwest of Baldridge in Pecos County. The new record was announced when the well was drilling at 21,716 ft. It became the state's deepest hole when it passed the old mark of 21,687 ft set last year by Pan American Petroleum Corporation No. 1-CS University, seven miles southeast of the Phillips test.

Drilling at the Phillips operation is in a sidetracked hole after the deepest whipstock operation ever attempted in Texas. Whipstock was set at 19,986 ft when a fishing job developed with original hole bottomed at 21,396 ft.

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CYPAN is available in 50-pound bags through Magnet Cove Barium Corporation, distributors in the United States and Canada (and in California, also available through Macco Corporation). Ask these drilling mud service companies for information on how CYPAN can help solve your drilling mud problems.

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RUNNING TOUR with MEN in the INDUSTRY

▸ **William R. Loar** has been named chief proration engineer for Sunray Mid-Continent Oil Company. Before his promotion, Loar was unitization engineer for Sunray. He replaces **Burns H. Errebo** who resigned to become associated with the law firm of Simms, Modrall, Seymour, Sperling and Roehl in Albuquerque, New Mexico.

W. R. Loar

Tom Frick

▸ **Tom Frick** has been named manager of Atlantic Refining Company's South Louisiana Region. Frick, formerly manager of the production division of the company's domestic crude oil production department, assumes his new duties in Lafayette, Louisiana, June 1.

F. W. Turner, formerly operations manager for the Dallas-Eastern Region, takes Frick's place as manager of the production division.

Frick joined Atlantic in 1941 as Southwest division job analyst and has since served in various operations capacities. He is a petroleum engineering graduate of the University of Tulsa. Turner, an Oklahoma A&M graduate, joined Atlantic in 1934 and has held various engineering supervisory positions in the Southwest and Venezuela.

▸ British American Oil Company, Ltd., announced the appointment of **E. J. Gallagher** as general manager of the production and pipeline department with headquarters in Calgary. **O. I. Torkelsen,** vice president, will assume executive duties relating to production and pipeline operations with headquarters in Toronto.

Torkelsen was formerly vice president and general manager of the production and pipeline department in Calgary, and Gallagher was formerly assistant general manager of the same department.

▸ **Lloyd D. Traupe,** senior geologist of the Ohio Oil Company's Houston production division, has been promoted to assistant division geologist.

▸ **Deane Baker** has been elected president of the newly formed Jersey Petroleum Corporation. Baker, also elected a director, is the principal officer of Deane Baker & Associates, a Texas petroleum management consulting firm.

Other officers include **W. Doyle Miller,** vice president and director; **Everett J. Canning,** director; **John M. Reed,** geologist and director and **Robert K. Berry,** director. Berry, president of Berry & Company, will act as financial advisor to the company.

▸ **John W. Butler** has been appointed Paris, France, representative of Phillips Petroleum Company's foreign department and will be engaged in the company's activities relating to recently acquired concessions in the Sahara desert of Algeria. **J. T. Clark** has been named to succeed Butler as chief geologist in Caracas, Venezuela. Clark had been manager of the company's Amarillo, Texas, land and geological division.

▸ Southern Geophysical Company of Fort Worth named 2 new officers, at the annual stockholders' meeting. **John L. Bible** of Houston, executive vice president, and **Elmer F. Blake,** of Denver, Colorado, vice president. Re-elected were **Frank Steen** of Fort Worth, secretary-treasurer, **Mrs. Hazel Dygert,** assistant secretary-treasurer, and **Dr. Sidon Harris,** president.

Bible heads the Houston office of the firm, and has been with Southern for two years. He was formerly president of Tidelands Exploration Company in Houston. Blake has been in charge of the firm's Rocky Mountain operations for a year, and was previously with Western Geophysical Company, National Geophysical Company, and Continental Geophysical Company.

In another action taken at the annual meeting, **R. L. Nash** was named manager of the company's New Orleans office. He had been supervisor of seismic operations in the Louisiana-Mississippi area for Southern.

▸ **Fred W. Forward** has been named manager of Phillips Petroleum Company's Evansville, Indiana, land and geological division, succeeding **Roy B. Ralston,** who has been appointed manager of the company's Amarillo, Texas, land and geological division. **Langdon G. Williams** has been promoted to the position of assistant division manager and division exploration geologist at Evansville, and **Neill F. Murphy,** from Wichita Falls, Texas, has been advanced to division landman for Phillips at Evansville, succeeding **R. W. Monroe,** who has been transferred to Wichita Falls.

▸ Officers and directors of the Jersey Production Research Company, newly formed exploration and production research affiliate of Standard Oil Company (New Jersey), are: president and a director **Dr. Carl O. Tongberg,** formerly a vice president and director of Carter Oil in charge of research; vice presidents and directors are **Max C. Sons,** and **R. C. Curtis,** also formerly of Carter Oil. Other directors are **M. A. Wright** and **Nelson Y. Ruth,** both of Standard Oil Company (New Jersey); **O. C. Wheeler,** International Petroleum Company, Ltd.; **W. D. C. Mackenzie,** Imperial Oil, Ltd.; **Guillermo Zuloaga,** Creole Petroleum Corporation; **Carl G. Herrington,** The Carter Oil Company; and **Dr. Charles L. Fleming,** Esso Research and Engineering Company. All companies represented by these men are affiliates of Jersey Standard.

▸ Newly elected officers of the Petty Geophysical Engineering Company are **David F. Tver,** executive vice president, and **Harry Mayne,** vice president of technical

D. F. Tver

Harry Mayne

services. Before becoming associated with Petty, Tver was with Anderson-Prichard Oil Corporation in Oklahoma City. Mayne is a 20-year veteran with Petty.

▸ **J. Howard Rambin Jr.** has been elected senior vice president in charge of The Texas Company's worldwide producing interests and activities. **A. W. Baucum** was named vice president in charge of the domestic producing department, succeeding Rambin.

A. W. Baucum

Eugene Prestera

▸ **Eugene Prestera,** a petroleum engineer formerly associated with Mene Grande Oil Company in Venezuela and with Continental Oil Company in the United States, heads the new service office opened by Reynolds Metals Company in Venezuela.

▸ International Petroleum Company, Ltd., has announced the appointment of **Howard C. Kauffmann Jr.** as assistant manager of operations at Talara, Peru. Kauffmann is presently production coordinator in International's executive office at Coral Gables, Florida.

▸ **Baxter Boyd** has been appointed geologist for Rowan Drilling Company, Inc. Boyd was formerly employed in the same capacity with the Continental Oil Company and more recently was vice president in charge of exploration for Republic Natural Gas Company.

▸ **Earl G. Bateman,** well known independent oil producer, was elected a director and **E. S. Doyle** advanced to vice president of production, Rimrock Tidelands,

E. G. Bateman

E. S. Doyle

Inc. Bateman, who heads the E. G. Bateman Drilling Company and Bateman Oil and Gas Company in New Orleans, previously served as a Rimrock director from January 1956 until June 1957.

Doyle, who became associated with Rimrock Tidelands when it merged with Trans-Tex Drilling Company last year, was promoted to vice president of production from production superintendent.

▸ **J. R. Blaisdell** has been promoted to assistant vice president of Seismograph Service Corporation, and **S. W. Fruehling** to vice president of SSC (International).

Blaisdell is personnel manager for SSC, with headquarters in Tulsa. Fruehling is manager of the firm's operations in Brazil, with headquarters in Rio de Janeiro.

▸ **John A. Nugent** has been appointed technical advisor in the Caracas office of International Petroleum Company, Ltd. He assumes the position formerly occupied by **Aden E. Stiles** who is retiring after 24 years of service with International and other Jersey Standard affiliates. Nugent will arrive in Venezuela the early part of August.

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Running Tour

▸ Drilling & Exploration Company, Inc. of Dallas increased its slate of directors from ten to twelve. Both new members elected are vice presidents of Drilexco, **Robert L. Rose** and **Guy R. Brainard Jr.**

Rose is also president of the Contract Drilling Subsidiary Companies. Previously Rose was associated with Union Oil Company of California in Los Angeles. Brainard was affiliated with the Lucerne Corporation as a vice president. In February 1956, he joined Drilling & Exploration Company and is head of the exploration and production departments.

R. L. Rose

G. R. Brainard Jr.

▸ **George W. Myers,** manager of Sun Oil Company's Michigan production division, will retire June 30 after 41 years with Sun Oil Company and 44 in the industry.

▸ **Dr. Herman Gunter,** state geologist and director of the Florida Geological Survey for more than 39 years, has retired. **Dr. Robert O. Vernon** has been named as his successor. Vernon has served as assistant state geologist and associate director.

▸ **Murray E. Body** has been appointed general manager of Tidewater Oil Company's operations in Turkey. Body succeeds **Martin H. Mitchell** who is returning to assume a post as assistant to **J. Earle Gray,** head of foreign exploration in San Francisco.

▸ **M. L. Terry,** division manager, Oklahoma division, will take early retirement from The Texas Company. Other changes in the domestic producing department are:

H. O. Woodruff, assistant general manager, Houston, will replace Terry as division manager, Oklahoma division, with headquarters at Tulsa. **S. T. McCardell,** assistant division manager of the Louisiana division, will be transferred from New Orleans to Houston to become assistant general manager, replacing Woodruff. **J. H. Markley Jr.,** assistant division manager of the West Texas division, will be transferred from Fort Worth to Houston to become assistant general manager. **Tom T. Freeman,** division manager of the Rocky Mountain division, is being transferred from Denver to the general manager's staff, Houston, as manager of land evaluations. **O. B. Hocker,** assistant division manager of the South Texas division, has been named division manager of the Rocky Mountain division and will move from Houston to Denver. **George H. Clark,** assistant to general manager, is being transferred to assistant division manager of the South Texas division, replacing Hocker.

▸ Two promotions in Sun Oil Company's industrial relations department for production have been announced. **Louis Davignon,** special assistant at Dallas, has been assigned to work with Venezuelan Sun Oil Company and will maintain an office at Maracaibo, Venezuela. He retains his title of special assistant. Venezuelan Sun is a subsidiary of Sun Oil Company. **William Ferrell** of Sun's industrial relations department at Dallas succeeds Davignon as special assistant in the Dallas office.

Four promotions in the geological department of Sun Oil's southwest production division with headquarters in Dallas are: **Dr. Edward W. Hard** is now geophysical coordinator. He replaces **Lee Smith,** who recently transferred to Venezuelan Sun Oil Company's Caracas office. Venezuelan Sun is a Sun Oil subsidiary. Succeeding Dr. Hard as regional geologist is **Ross H. Ley,** formerly district geologist at Midland, Texas. Advancing to division paleontologist with offices at the company's production research laboratory at Richardson, Texas, is **John Means,** formerly assistant division paleontologist. He succeeds the late Dr. I. B. Hamilton, who died February 3. At Midland, **Fred Smyth,** assistant district geologist, succeeds Ley as district geologist.

▸ **W. E. Stiles,** vice president in charge of engineering and production and **Eddie J. Hudson,** petroleum engineer, have resigned from Buffalo Oil Company to establish the firm of W. E. Stiles Engineering. The new consulting petroleum engineering firm, located in the Mayo Building, Tulsa, will engage in oil and gas property evaluation, reservoir studies, unitization, and all phases of engineering problems dealing with primary and secondary recovery operations.

W. E. Stiles

E. J. Hudson

▸ **E. Charles Patton** has anounced his resignation as chief engineer of Tekoil Corporation to engage in oil producing activities as an independent operator. He has been associated with Tekoil since last September, when the firm acquired Reservoir Engineering Laboratories, Inc., which he had served as president. Formerly in charge of reservoir engineering and related laboratory work for Magnolia Petroleum Company, Patton was the 1948 recipient of the Raymond Memorial Award of the Society of Petroleum Engineers for his work in reservoir engineering.

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For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

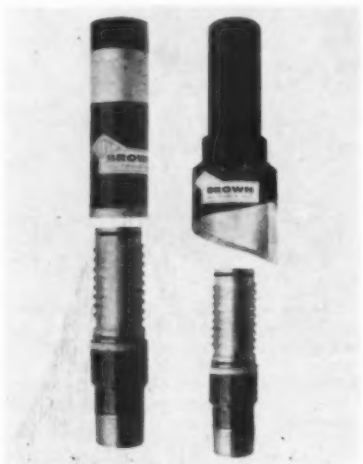
Solid Master Bushing

The National Supply Company has developed a solid master bushing for its type MS-27½ rotary. Intended for deep drilling, the new bushing has a solid outer body of alloy steel that absorbs all thrust or transverse load induced by the vertical load of the drill string against the tapered bowl. The 2 halves of the inner bowl can be removed separately, if desired, or the body and the inner bowl can be removed in a single load. Driving surfaces of the body and bowl are flame-hardened for greater wear resistance and longer life. *The National Supply Co.*

Circle number (1) on reply card.

Criss-Cross Safety Joint

A safety joint which affords right-hand release and right-hand re-engagement for retrieving fish has been developed by Brown Oil Tools, Inc. The lower pin end is provided with a criss-cross right and left-hand thread to permit right-hand release.

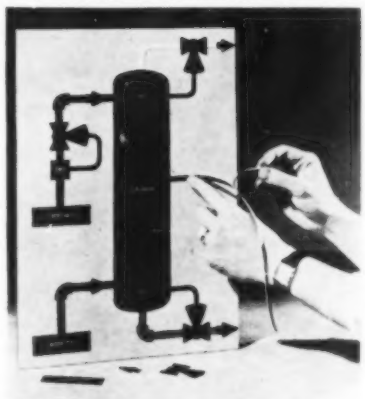


If stuck fish cannot be retrieved, the retrieving head can be released by left-hand rotation. An anti-friction ring prevents making the retrieving head too tight by right-hand rotation in order that no difficulty will be experienced releasing the retrieving head with left-hand rotation. *Brown Oil Tools, Inc.*

Circle number (2) on reply card.

Graphic Panel-Board Symbols

Pressure-sensitive graphic symbols that simplify panel-board manufacture are being used by Panellit, Inc., on graphic panel-boards designed for automatic control and information systems produced by the firm. Symbols are available in a wide range of colors. Made of a pressure-sensitive plastic, lines and symbols can be applied on painted steel panels or Formica-aluminum panels. Flexibility of the material makes it ideal for preliminary mockups in the design stages.



Symbols are dimensionally stable and resist chemical atmospheres. Lettering for nameplates and other process identification is engraved directly into the material. *Panellit Inc.*

Circle number (3) on reply card.

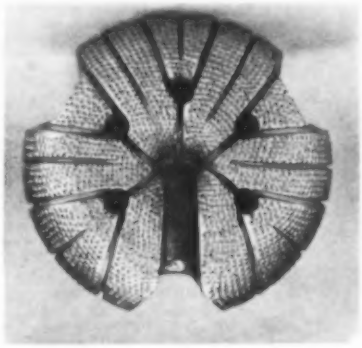
Geared Head Socket Wrenches

The X-4 Corporation has announced the addition of a new larger wrench to their line of geared head wrenches and also a new line of large socket wrenches. The new model is rated at 4000 ft-lb with a 1-in. input drive and 1½-in. output drive. Torque range covered by these tools range from a few hundred ft-lb to 4000 ft-lb. Sockets can be produced from 1½ in. to 8 in. or larger without special tooling. *The X-4 Corporation.*

Circle number (4) on reply card.

Slotted Diamond Drill Bit

A new diamond drill bit has been introduced by Hycalog, Inc. Called the "V-Door," it incorporates a concept in bit design which has been developed for making long runs in hard formations.

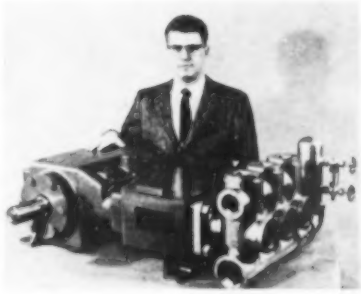


In order to prevent plugging of the center section, the bit actually cuts a small core. Then, by a combination of hydraulics and bit design, the core is broken off in short segments and washed through the V-door slot out of the hole. *Hycalog, Inc.*

Circle number (5) on reply card.

Corrosion-Resistant Power Pump

A new power pump is being manufactured at Worthington Corporation's Oil City Division. The pump has been developed as an inexpensive waterflood and salt water disposal pump and is manufactured in corrosion-resistant aluminum bronze.



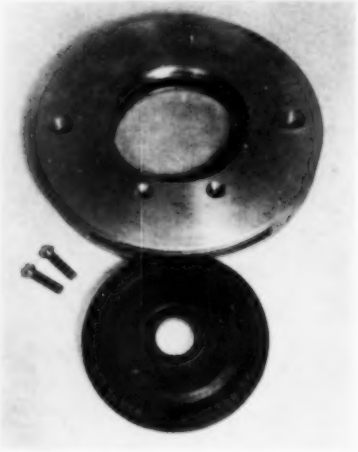
Features of the pump include interchangeable plungers, straight-flow design for maximum volumetric efficiency, and large pipe connections, 3-in. suction and 2 in. discharge on either side. *Worthington Corporation.*

Circle number (6) on reply card.

New Equipment

Pipe Wiper and Junk Guard

A new product answers the need for a wiper that remains stationary relative to the tubing head instead of riding up with the pipe. The 9-in. Petromec pipe wiper is held in place by a special 6-in. API flange, in which the wiper is inserted. This flange is attached to the tubing head. There is sufficient vertical and lateral movement of the wiper to minimize wear. Mud and oil are kept below the rig floor and housekeeping is improved.



The wiper can also be used with the kelly rotating through it. In this application the wiper acts as a junk guard, keeping the hole covered at all times and preventing costly damage from fallen junk. *Petromec.*

Circle number (7) on reply card.

New Jet Perforating Tool

Introduction of a new perforating tool by The Western Company has been announced. The tool incorporates a carrotless jet charge on an expendable aluminum carrier. The tool can be used in 4½-in., 5½-in., and 7-in. casing with optimum stand-off between gun and casing. Shot densities are 1 to 4 per ft, and the gun may be run in lengths up to 100 ft.

Bottom firing mechanism allows bottom-up firing order, eliminating the danger of shooting the gun in two and leaving unfired charges in the bottom of the hole. Carrier and charge cases are virtually pulverized during firing, and residue is acid soluble and drillable. *The Western Company.*

Circle number (8) on reply card.

Surface Tubing Caliper Service

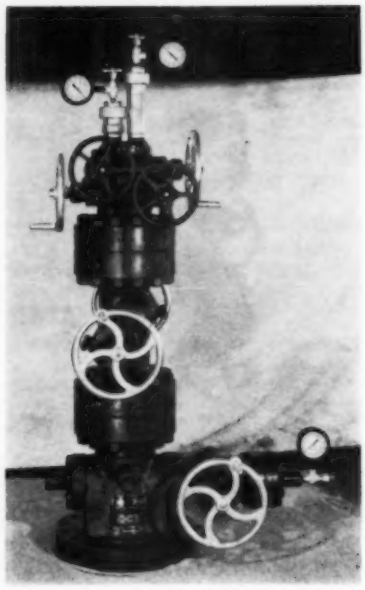
Otis Engineering has announced its newly-developed "surface" caliper survey service designed to detect defective joints in tubing before the pipe is run into a well. The service is especially recommended for surveying tubing that will be set in corrosive, high-pressure wells.

A special calipering instrument is drawn through the joint to determine internal condition of pipe. Feelers on the caliper contact the inside wall of the pipe and as a corrosion pit or reduction in wall thickness is encountered, outward movement of feelers causes an electrical signal to be transmitted to a strip-chart recorder. Internal condition of pipe is logged and each joint classified and color-coded. Service includes a detailed report on the classification of each joint. *Otis Engineering Corp.*

Circle number (9) on reply card.

Parallel Dual Flow Control

A parallel dual flow control has been developed by the Oil Center Tool Company. One flow control is integrally placed above another, reducing the number of crosses, wing valves, and choke assemblies used.



The dual flow control is installed on top of the master valve. However, the design allows the use of bottomhole test adapters as in other flow control models. Operator can switch the flow from one size choke to another without closing in the well. *Oil Center Tool Company.*

Circle number (10) on reply card.

Calibrated Flow Control Valve

A new flow control valve, used for controlling the flow rate of gas or liquids, has been announced by Merla Tool Corporation. Straight line increase of flow is controlled by a plug-type, proportioning, hardened valve. A stainless steel, "O" ring sealed seat eliminates eccentricity and is easily replaced. Removal of threaded stuffing box cap makes all parts easily accessible for inspection or replacement.

A calibrated handle offers micrometer adjustment in tenths of turns with complete turns calibrated on an indicator. Handle can be locked in any position with a set screw. *Merla Tool Corporation.*

Circle number (11) on reply card.

Percussion Drilling Tool

A new percussion drilling tool, the Schramm Rotatool, makes possible fast drilling in hard rock formations that stop ordinary rotary drills. The tool was developed for use with Schramm Rotadrills and has only 3 moving parts. Percussive action is completely contained within the tool and no power is lost through the drill pipe. Bit is equipped with 6 carbide tips which can be reground on the job.

Tool is available in 2 models. No. 3875 takes a 4½-in. bit and requires 100 cfm of air at 100 psi to operate. The larger size, No. 5250, takes 6-in. and 6½-in. bits and requires 350 cfm of air to operate. *Schramm, Inc.*

Circle number (12) on reply card.

Jet Strainer for Waterflood Service

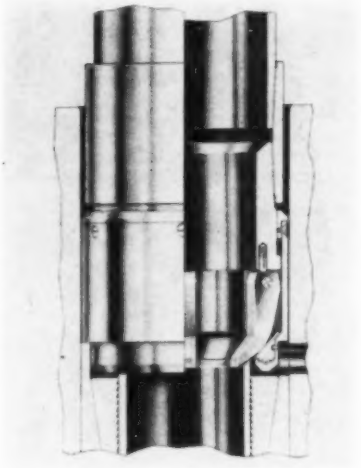
A jet type strainer, manufactured by Thornhill-Craver Company, is designed to remove solids, algae, and bacteria from flood water to any desired degree down to sub-micron particle size. The strainer employs a stainless Dutch twill screen, as fine as 400 mesh, spot welded to a monel basket. With a diatomaceous earth precoat, the screen will remove solids down to particle sizes of 1 micron, or less, as well as bacteria and algae.

A pressure-differential gage indicates when the strainer needs cleaning. The basket is jetted clean by means of hydraulic impact. Or, the cleaning operation may be made automatic with electronic controls. The strainers are made in 300, 600, and 900 gpm sizes. *Thornhill-Craver Company.*

Circle number (13) on reply card.

Overshot-Type Casing Cutter

A new overshot-type casing cutter has been placed in service by Cosasco Division of Perfect Circle Corporation. The cutting device makes beveled cuts to close tolerances using the drilling rig's rotary table to power the cutter.



Casing is landed in the wellhead and the hollow cutter is lowered over the casing against the wellhead spider. A torque tube drive sleeve connects the cutting tool with the slips of the rotary table. Guided by the wellhead bore, carbide-tipped knives make the beveled cut. *Perfect Circle Corporation.*

Circle number (14) on reply card.

Drilling-Producing Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

Heat Transfer Centrifugal Pumps

For the pumping of liquids which congeal, solidify or crystallize with loss of heat, Dean Brothers Pumps Inc., offers a line of standard centrifugal pumps described in Circular No. 195. Labelled "constant temperature" pumps, they are designed to transfer heat to the liquid as it passes through the pump.

Circular outlines operation of the pump and includes photographs, sectional drawings of the pump as well as mechanical design secifications and materials of construction of steam tracing. *Dean Brothers Pumps Inc.*

Circle number (15) on reply card.

Air Photo Studies in Geology

How air photo interpretation provides essential soils and geologic data for engineering projects is reported in a new 4-page folder published by Aero Service Corporation. The folder also discusses the use of air photo studies to locate construction materials, determine trouble areas, and to investigate excavation and foundation problems. Several examples of air photo interpretation are shown. *Aero Service Corporation.*

Circle number (16) on reply card.

Wire Rope Storage

A new bulletin on the storage and lubrication of wire rope has been announced by Leschen Wire Rope Division, H. K. Porter Company, Inc. The proper procedures to follow when either new or used rope is to be stored are described as are the various steps to take when the rope is put back into service. The need for proper lubrication is also discussed, together with a number of methods by which lubricants may be applied. *Leschen Wire Rope Division, H. K. Porter Company, Inc.*

Circle number (17) on reply card.

Hard-Faced Subsurface Plunger

Axelson's new Axite plunger brochure graphically describes manufacturing details of their Axite hard-faced subsurface plunger. Axite processed plungers have a hardness closely approaching that of diamonds. This extreme hardness extends plunger life and is particularly good when abrasion and wear resistant qualities are desired. *The Axelson Manufacturing Company.*

Circle number (18) on reply card.

Highway Regulations for Truckers

The new 1958 edition of Truck and Trailer Size and Weight Restrictions, a pocket-size booklet compiling the laws of all 48 states and the District of Columbia regulating size and weight of trucks and trailers, has been prepared by the research department of the Four Wheel Drive Auto Company. The booklet has been prepared with the assistance of state officials, who have checked and approved the regulations and interpretations relative to their individual states. Data presented in most cases are likely to hold until mid-1959. *Four-Wheel Drive Auto Company.*

Circle number (19) on reply card.

Geared Motor Coupling

A folder describing Link-Belt's new MC geared coupling has been released. Folder 2875 details application and selection data for the couplings, which are designed especially for use as a motor couplings. Basic principles of operation are like those of a conventional geared coupling, i.e., externally geared hubs are mounted on the shafts and joined flexibly by an internally geared sleeve. Power transmitting parts are steel and fully machined.

The MC coupling is of 1-piece design, and the coupling is enclosed in a 2-piece metal cover, which is sealed to prevent loss of lubricant or entry of contaminants. *Link-Belt Company.*

Circle number (20) on reply card.

Two-Column Gas Chromatography

Time-saving benefits of 2-column gas chromatography, using the Beckman dual-column valve, are described and illustrated in new 4-page data sheet GC-82-MI. Application information features uses and advantages of 2-column operation with Beckman gas chromatographs. *Beckman/Scientific Instruments Division.*

Circle number (21) on reply card.

Oil Equipment Catalog

The Oil Equipment Division of A. Y. McDonald Manufacturing Company has announced publication of a new catalog listing their complete line of equipment for handling liquid petroleum products. The catalog contains full information and specifications on service station equipment, bulk plant equipment, truck tank equipment, and specialties for farm or general dispensing units. *Oil Equipment Division, A. Y. McDonald Manufacturing Company.*

Circle number (22) on reply card.

Steel Jacketed Plastic Pipe

A 4-page pamphlet containing information about a newy-developed rigid plastic pipe encased in a steel jacket has been prepared by Jones & Laughin Steel Corporation. The product, known as "Jal-Jacket", combines the pressure-retaining strength of steel pipe with the chemical resisting qualities of unplasticized polyvinyl chloride pipe. The pamphlet contains specifications, line drawings and other pertinent information. *Jones & Laughlin Steel Corporation.*

Circle number (23) on reply card.

Static-Magnetic Annunciator

A 4-page folder describing a new type of annunciator is available from the Panalarm Division of Panellit, Inc. The folder contains information on Panellit's static-magnetic annunciator developed for monitoring complex automatic machine and continuous process operations. The annunciator uses static-magnetic controls in place of relays. They have no moving parts, resulting in a high degree of reliability and reduced maintenance. *Panellit, Inc.*

Circle number (24) on reply card.

Oilfield Torque Converters

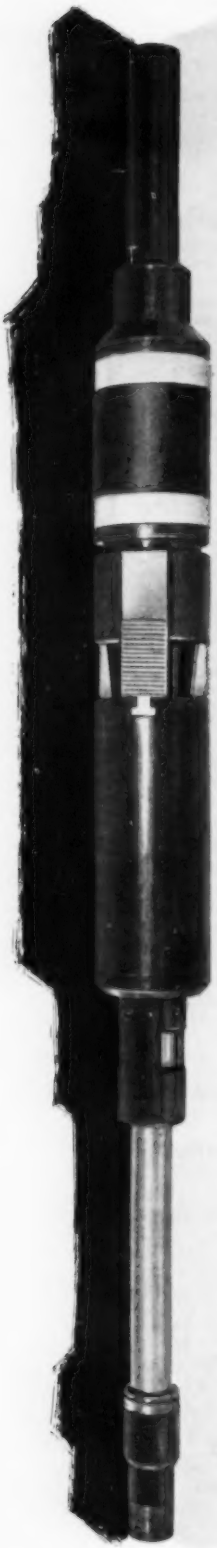
Torque converters for oilfield service are described in new Bulletin 469 by The National Supply Company. It tells how to drill faster, more efficiently, and make machinery last longer. Operation of National torque converters is hoisting, pumping, and rotary operation is explained and illustrated. A converter selection chart covers the 100 to 1000-hp range of 6 sizes and 17 hydraulic circuits. *The National Supply Company.*

Circle number (25) on reply card.

Liquid Ring Transfer Pump

A new self-priming liquid ring pump for transfer and similar applications is described in a bulletin issued by Goulds Pumps, Inc. This lightweight pump handles air alone, liquid alone or any combination of air and liquid. It is designed for permanent installation or portable utility use. Specifications, performance curves and construction data are included. *Goulds Pumps, Inc.*

Circle number (26) on reply card.



An entirely new concept

HYDRAULIC SET RETRIEVABLE PACKERS

In line with a long-standing policy to provide maximum safety for equipment and personnel in well completion and workover operations, Brown Oil Tools, Inc. now offers an entirely new and different type packer to the industry.

After extensive field tests, the Hydraulic Set Retrievable Packer is now available in a complete line of standard casing sizes for single, dual, triple, and quadruple string completions.

Deeper production, higher pressures, and heavier muds have all dictated the need for this packer. The Brown Hydraulic Set Retrievable Packer not only answers the need, but gives many additional advantages.

This type packer, for instance, makes it possible to run any number of single or multiple string packers on the number one tubing string. All other tubing strings are then run and landed, and the well head installed with the completion fluid in all strings and the annulus. Well fluid (mud) is changed over as desired and all zones washed in. The packers can then be set simultaneously or set and tested individually. No wire line manipulation is required in the setting procedure.

Additional information on this revolutionary new packer can be obtained by contacting the nearest Brown Representative or Distributor. Or write to Brown Oil Tools, Inc., 8490 Katy Road, Houston, Texas.

BROWN HS-8-1 PACKER

BROWN
OIL TOOLS, INC.

8490 Katy Road, Houston, Texas.

MWL Tool & Supply, Midland, Texas, and Hobbs, N. Mexico; Regan Forge & Engr. Co., San Pedro, Calif.; Consolidated Service Co., Casper, Wyo. Acme Well Supply, New York City; Import Tool Co., Edmonton and Calgary, Alberta, Canada; A-Z Export, S.A., Maracaibo and Puerto LaCruz, Venezuela; Miguel Rocca, Mexico City.

"B&W helps me match the tube to the job

As a design engineer, I work with all types of steel heat exchanger tubing. B&W can produce all of our requirements, in the grades, sizes and types I need."

It's true. Whatever your steel heat exchanger tubing requirements may be, B&W can meet them promptly and dependably. Take a look at the scope of B&W's operations in this field—seamless and welded stainless steel tubing, seamless and welded carbon steel tubing, seamless alloy steel tubing—with heat treatment, mechanical properties, surface finish, tolerances and length matched to the job.

What's more, B&W district sales offices in principal cities from coast to coast along with three manufacturing locations insure prompt handling of your tubing requirements. You can depend on B&W, too, for assistance in selecting the tube which will meet all of the requisites of fabrication and end use service. Call on Mr. Tubes, your local B&W district sales representative, or write for Bulletin TB-329. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

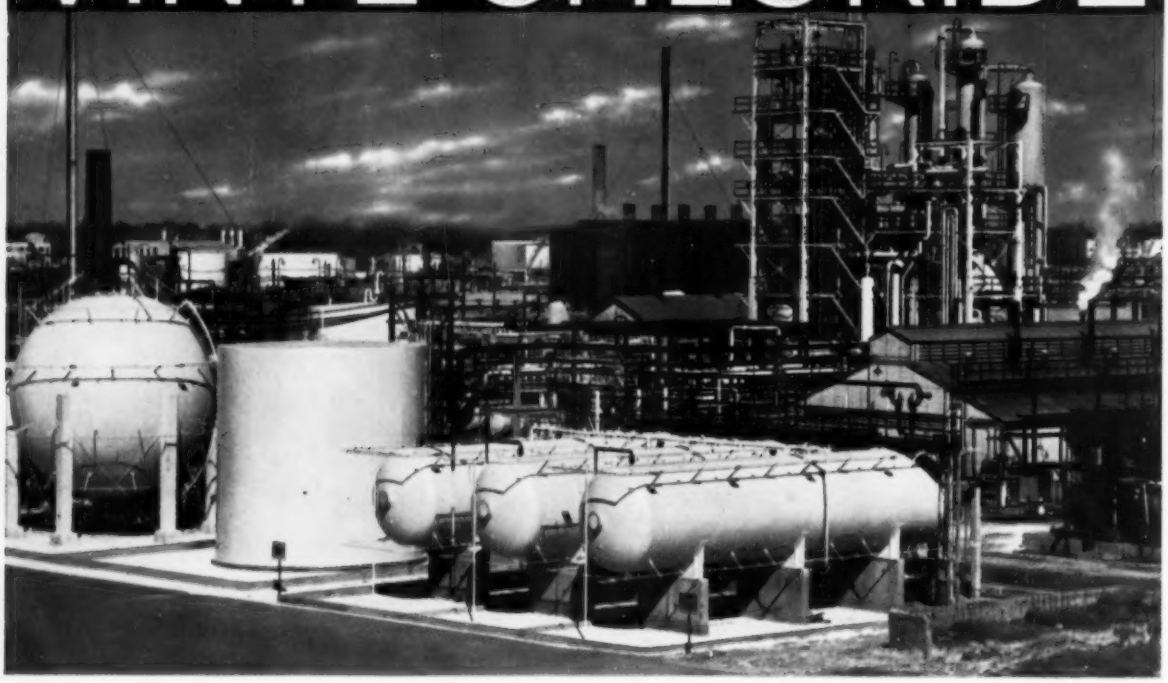
B&W
TUBULAR PRODUCTS DIVISION

TA-8008-PPI

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals.

Ethyl Corporation

VINYL CHLORIDE



plant engineered
and constructed by

CATALYTIC

Ethyl Corporation selected CATALYTIC for the engineering, procurement, and construction of its new Vinyl Chloride Plant. Close cooperation and coordination between Ethyl and CATALYTIC, utilizing to the fullest their joint experience with chlorinated hydrocarbons, resulted in successful on-stream operation of this plant within the scheduled completion time and budget.

CATALYTIC Construction Company

Philadelphia 2, Pennsylvania
Baton Rouge, Louisiana
Toledo, Ohio
Tulsa, Oklahoma

In Canada: Catalytic Construction of Canada, Limited; Sarnia, Ontario; Toronto, Ontario; Montreal, Quebec

Catalytic *On-Time*... *On-Budget* Services
for the metallurgical, chemical, petrochemical and oil refining industries: Project Analysis; Process Development; Process Design; Economic Studies; Engineering; Procurement; Construction.

New Projects in refining gas processing petrochemicals

Husky Oil Company will do research in carbonization and petrochemicals in a char plant leased at Red Lodge, Montana. The Cody, Wyoming, firm also holds an option to purchase the plant at the end of a year for $450,000 — the plant was put up for lease after shutdown for lack of funds. Lessor is Koal Crudes, Inc.

Completion of a 25 percent expansion in capacity of microcrystalline wax facilities at Petrolia, Pennsylvania, is announced by L. Sonneborn Sons, Inc. Expansion, according to Sonneborn, was in response to heavy industry demand for the plastic, flexible waxes coming into increasing use in food packaging.

New asphalt plant in Canada. Imperial Oil Company, Ltd., will build a 1500 bbl per day asphalt plant at its Edmonton, Alberta, refinery. Engineering work is underway, construction contract is scheduled for award this summer. Completion is scheduled for next Spring. Estimated cost is $1.4 million, equipment will include a continuous oxidizer and seven 10,000 bbl storage tanks.

A 25,000 Mcf per day gas processing plant will be built in Tenas Parish, Louisiana, by the N. H. Wheless Oil Company and the Feazel interests. Plant will process gas from the Rodney field in Jefferson County, Mississippi, will recover natural gasoline and lighter liquids.

Phillips expands private atomic research. Two new "atom smashers," which will be among the most powerful in industrial use, will be installed at Phillips Petroleum Company's Research Center at Bartlesville, Oklahoma, to expand the company's private research in the field of nuclear radiation. When completed and in operation during latter part of 1958, Phillips plans activities in investigating nuclear radiation effects on petroleum and petrochemical products and processes. For the past several years, Phillips has been conducting experiments with radiation purchased from Government facilities. The accelerators have been purchased from Applied Radiation Corporation.

Brazilian refinery expansion. Foster Wheeler Corporation has signed a contract with Petroleo Brasileiro S. A. (Petrobras) for the new Duque de Caxias Refinery near Rio de Janeiro, Brazil. The contract, expected to exceed $40 million, will comprise a complete 90,000 bbl per day refinery including crude distillation, catalytic cracking, catalytic reforming, propane decarbonization and treating processes, steam and power generating equipment, tankage and other off-site facilities. Completion will require more than two years.

A $500,000 plus pilot plant will be built by Polymer Corporation, Ltd., at its Sarnia, Ontario, plant. Described as a "diversified hydrocarbon" unit, it will be used to list stereospecific catalysts for new synthetic rubbers. Company is also finishing a $1.2 million addition to its R & D laboratories.

El Paso Natural Gas Company will build a $5 million, 250-million cu ft per day gas processing plant at Opal, Wyoming. Unit will recover propane and natural gasoline. Fluor Corporation will design and build the plant; completion is scheduled for early 1959.

Refinery capacity will be boosted 20 percent at Southern Mobile Oil Company's Buffalo, New York, plant. A 28,500 bbl per day crude distillation unit is slated for construction, and planned to go onstream late this year.

A half-dozen major refinery units are nearing completion at Magnolia Petroleum Company's Beaumont, Texas, plant. They include: (1) A highly mechanized blending and packaging plant; (2) an alkylation unit; (3) a 30,000 bbl-per-day Sovafiner unit; (4) a plant for recovery of hydrogen sulfide from liquid and gas feed stocks going to the new alkylation; (5) expansion of the liquefied petroleum gas fractionation system, including a new 200-ton deisobutanizer tower; (6) a 100,000 bbl-per-day crude oil distillation unit. Foster Wheeler Corporation is contractor for the Sovafiner, hydrogen sufide recovery system and the new crude distillation unit. Contractor for the LPG expansion is Fluor Corporation, and for the alkylation unit, C. F. Braun and Company. Magnolia served as its own general contractor for the blending and packaging plant.

A high-purity isobutylene plant is under construction in Houston, Texas, by Petro-Tex Chemical Corporation. The manufactured product will be above 99 percent purity, it is stated, and will be available in pressure type tank cars in December of this year.

These fractionators, each nearly 100 ft high, have been erected at Bakersfield, California, as part of the refinery's $4-million expansion program. Towers will serve a catalytic reformer capable of processing 210,000 gal daily of motor fuel blending component. The vessels were fabricated for the Standard Oil Company of California refinery by Kaiser Steel's Fabricating Division. Bechtel Corporation, San Francisco, is the engineer and constructor.

ETHYL RESEARCH APPRAISES VOLATILITY PROBLEMS OF FUTURE FUELS

Another important phase of octane improvement cost studies which must be balanced with engine requirements

Volatility cannot be separated from octane improvement cost studies of present day and future fuels. Exactly how much effect volatility will have upon cost studies will depend upon the individual refining situation and the value and/or availability of various pressurizing materials.

Studies in this field show that volatility is frequently a limiting factor in fuel composition.

Volatility and Engine Appetite

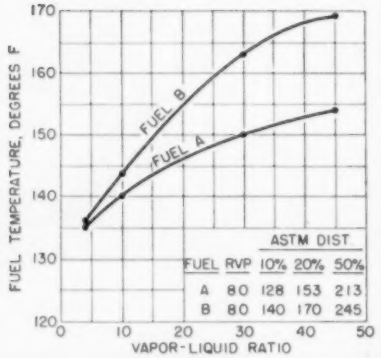
The importance of volatility as it relates to cost of octane improvement cannot be minimized. Yet engine acceptance of proposed volatility specifications must be given careful consideration. This is not always a straightforward comparison with previously marketed products.

Studies of refining trends made by Ethyl engineers indicate that volatility control of future fuels may become a subject for very careful appraisal as it relates to satisfactory engine performance.

Refining Trend— To More Aromatics

The refining trend within the next few years is toward higher aromatic fuels. Refinery practices such as splitting reformate, extraction of aromatics, and allocating more feed to the reformer all will be contributing factors. As more aromatics are blended to gasoline, there is an attendant decrease of mid-volatility

FIG. 1
EFFECT OF ASTM DISTILLATION ON THE VAPOR-FORMING CHARACTERISTICS OF GASOLINE



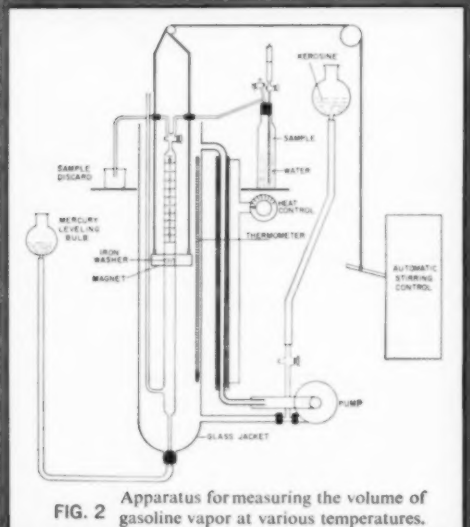
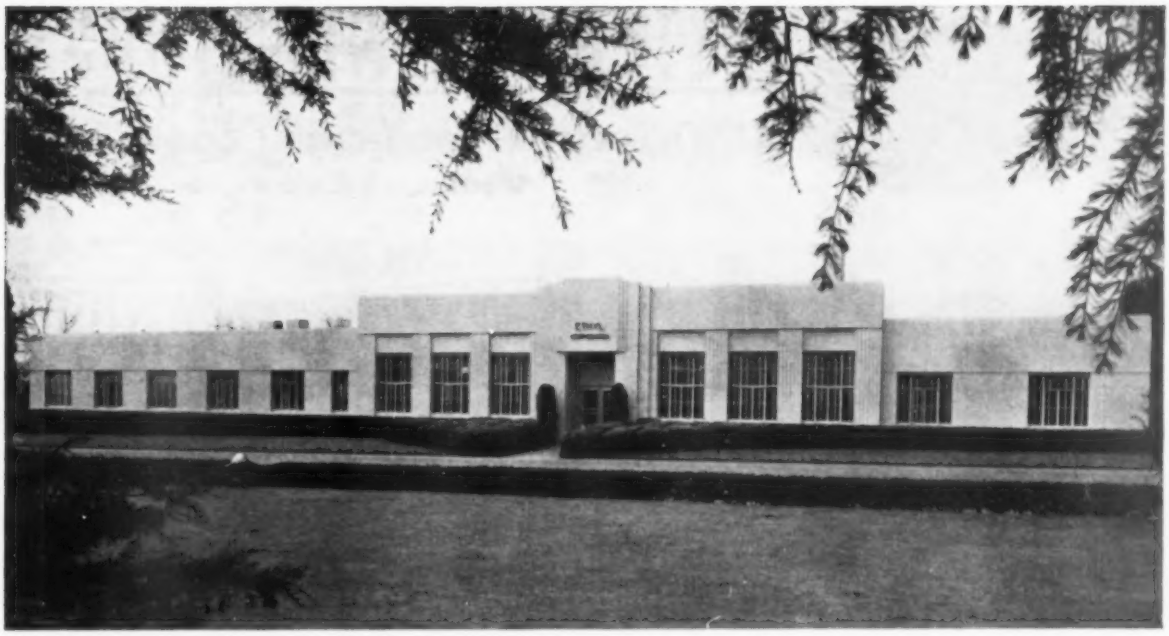


FIG. 2 Apparatus for measuring the volume of gasoline vapor at various temperatures.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



ETHYL'S SAN BERNARDINO LABORATORY is ideally situated and well equipped for general studies of fuel volatility. Maximum daytime temperatures near 100°F. prevail throughout the long summers. Suitable test roads are available at various altitudes.

as shown by the ASTM distillation curve.

Ethyl experience has shown that this frequently will hamper warm-up characteristics of today's engines. *Warm-up* has been given very careful consideration in Ethyl fuel studies since this is a vital aspect of mid-volatility.

Very often mid-volatility problems will require complete rebuilding of the fuel with maximum use of light blending components such as iso-pentane.

Precautions with Iso-Pentane

From the standpoint of engine acceptance, iso-pentane must be carefully appraised. Vapor lock is probably the most important single factor that must be considered. Vapor formation proceeds at a very rapid rate in fuels that are pressurized with large quantities of less volatile pentane, once designed-for fuel temperatures are exceeded.

An evaluation must be made for any volatility change. However, more care must be exercised in the control of a pentane-pressurized fuel than one adjusted with butane since more severe vapor locking difficulties can result during unseasonably hot weather.

Can Vapor Lock Tendencies Be Estimated?

The rates of vapor formation at various temperatures determine the relative vapor locking tendencies of gasolines. Vapor formation is not necessarily related to Reid vapor pressure alone.

One method of arriving at this information is shown in Fig. 1. Two fuels of the same Reid vapor pressure but different ASTM distillation curves are indicated. Fuel A produced 30 volumes of vapor per volume of liquid at 150°F., whereas Fuel B formed only 16 volumes at the same temperature.

The above type information (temperature V/L values) may be calculated from usual gasoline inspection data using Coordinating Research Council procedures.

Experience may then relate the temperature—V/L values to vapor locking tendencies of cars under seasonal conditions for the area of interest. Such an appraisal permits a more accurate specification of desired front-end volatility.

Frequently it is necessary to cross-check temperature V/L values of fuels having unusual distillation characteristics by an experimental procedure. Apparatus for such laboratory work is described in Fig. 2. This equipment is available at the San Bernardino branch of Ethyl Corporation's Research Laboratories.

Other facilities there include a gasoline testing laboratory, and a chassis dynamometer which operates under controlled temperature, wind and velocity conditions. Ethyl Technical personnel have frequently used these facilities in cooperation with refiners for studies of their gasoline volatility problems.

HOW ETHYL RESEARCH IS HELPING YOU

The Refining Industry is constantly studying volatility of future fuels as it relates to octane improvement.

Ethyl Corporation Refinery Technologists have recently made a precise study of butane and pentane to establish the octane blending values of these pressurizing agents in several refinery stocks.

Refining trends indicate that iso-pentane will find a position in future fuels for octane improvement and volatility control. Future fuel volatility should be carefully appraised from the standpoint of engine acceptance. Assistance in such studies, based on over 30 years' experience in fuel-engine relationships, is available from Ethyl's Research Laboratories.

For further information, just call your Ethyl Representative.

ETHYL CORPORATION
New York 17, N. Y.

ETHYL
ANTIKNOCK COMPOUND
ETHYL CORPORATION

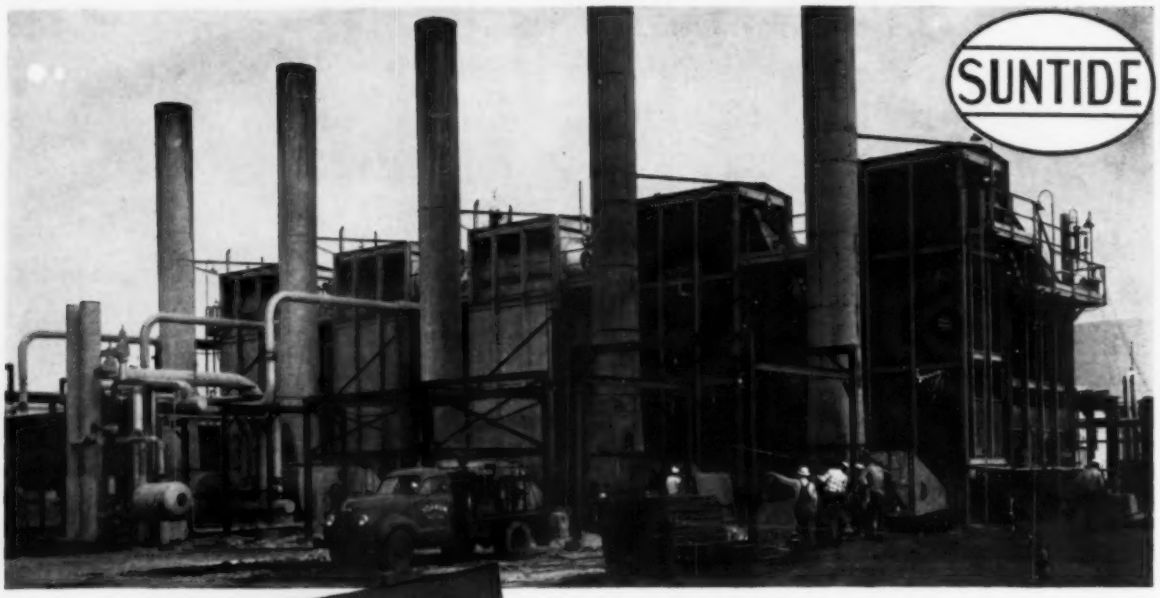
RESEARCH LABORATORIES:
1600 W. Eight Mile Road, Ferndale 20, Mich.
2600 Cajon Road, San Bernardino, Calif.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Vogt STEAM GENERATORS

at SUNTIDE REFINING COMPANY

Viola, Texas



Above: *Cross Section showing arrangement of steam and water drums, tubes, baffles, and furnace.*

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YOUR API DIVISION OF REFINING MIDYEAR MEETING IN REVIEW

Here, summarized for quick, informative reading, are highlights of all papers given at this key refining meeting

PROCESSES — FIRST SESSION

Presiding: H. Y. Hyde, vice president-manufacturing, Tidewater Oil Company, San Francisco, California.

[*Session developed by F. C. Moriarty, Aurora Gasoline Company, Detroit, Michigan.*]

Bulk Acid Polymerization for Motor Gasoline.

E. D. Kane† and G. E. Langlois
California Research Corporation, Richmond, California

A new process for polymerizing propylene or mixed propylene-butenes feed to produce high-octane motor-gasoline blending stock is described. Process uses phosphoric acid as the catalyst, but in unsupported liquid form rather than in a conventional fixed bed. Hydrocarbon feed and the acid catalyst are contacted in a novel, high-efficiency, orifice-plate reactor.

Main advantages are excellent temperature control, high olefin conversion, simplified product recovery, and high operating factor because of the ability to replace spent catalyst without plant shutdown.

Product yield and quality, effects of operating variables, catalyst life, materials selection, and performance of a 100-bbl per day demonstration plant are discussed.

Use of liquid phosphoric acid results in much smaller reactors. Cost of a bulk acid plant designed for 95 percent olefin conversion would be equal to that of a 90 percent conversion fixed-bed plant, or less than the fixed-bed plant at the same conversion. Smaller reactor-section equipment also means savings in site costs, particularly since no site facilities are needed for loading and unloading solid catalyst-support materials.

Excellent temperature control is an outstanding operating advantage and is achieved without recycling propane or butane for quench.

Operating experience in demonstration plant showed that a bulk acid unit can be started up quickly, typically in one or two hours, as compared with eight to sixteen hours for fixed-bed units.

Trends in the Production of High-Quality Motor Fuels.

M. J. Sterba, Davis Read† and Nellson R. Adams
Universal Oil Products Company, Des Plaines, Illinois

This paper presents data to illustrate the trend toward manufacturing of gasolines with increased concentration of high-purity, chemical-grade hydrocarbons. Data are also presented to show the chemical composition of refinery pool gasolines and application of the basic refining processes of Platforming, Penex isomerization, alkylation, and Udex extraction to produce high-quality motor fuel.

Five basic processing techniques were used to produce pool gasolines with leaded RON varying progressively from 97.4 to 102.0. Principal factors involved in achieving this result were: 1, stepwise use of C_4 and C_3 HF alkylation; 2, addition of isomerization of n-pentane and n-hexane; and 3, Platforming of C_7+ naphtha rather than a lower-boiling C_6+ fraction.

Order in which these steps would be taken in a particular refinery would not necessarily coincide with the numerical order expressed in the foregoing. Also, variation in Platforming severity, or product octane level, is readily applicable to all five processing techniques, in fact, causes overlapping of leaded octane levels for the various cases.

Chemical composition, hence the road performance, of refinery pool gasolines can be improved considerably by installation of alkylation and isomerization to produce isoparaffins — preferably in the order mentioned. Use of Udex extraction to segregate high-octane aromatic blending component from the Platformates is also demonstrated.

Availability of extraneous isobutane and n-butane is an important consideration in stepwise process selection. Catalytic polymerization is considered basic, including Platforming at any octane level, to minimize excess C_3 and C_4 hydrocarbon production which might otherwise have fuel value.

Platforming severity is the obvious tool which a refiner in such a position can utilize to increase pool octane level. If, however, a refiner desires to eliminate discard of excess butanes while raising pool octane level, he turns logically to butylene HF alkylation with polymerization of propylene only. The refiner can be self-sufficient on butane balance or, preferably, draw on limited outside iso- and n-butane sources.

If iso- and n-butane are available in relatively unlimited quantities, alkylation of all recoverable propylene and butylenes is advantageous in obtaining overall octane increase in conjunction with controlled Platforming octane level. In addition, isomerization of n-pentane can add approximately

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*The 23rd Midyear Meeting of the American Petroleum Institute's Division of Refining was held in the Statler Hotel, Los Angeles, California, May 12-16, 1958. For copies of the papers — supply is limited — contact the American Petroleum Institute, Department of Information, 50 West 50th Street, New York 20, New York.

†Indicates co-author presenting paper.

**All claims, conclusions, etc., set forth in these summaries are at least a portion of those presented in preprints of the papers scheduled for presentation. Publication herein does not constitute, in any manner whatsoever, endorsement or verification by the editors of THE REFINING ENGINEER.

six-tenths of an octane number to the leaded RON of pool gasoline at any Platforming severity.

Additional octane improvement involves combination of two major process changes: Adding C_6 Penex and simultaneously removing virgin C_6 fraction from Platformer charge to provide virgin hexane for isomerization. Secondary result is that removal of the C_6 fraction from Platformer charge permits increase in ceiling octane level.

Catalytic Cracking Feed Preparation.

W. V. Medlin,† J. C. Ornea, and A. J. Johnson, Shell Development Company, Emeryville, California.

Catalytic cracking is an important tool for production of high-quality gasoline. The trend in feed preparation is to produce larger quantities of distillates suitable for catalytic cracking feed. Most desirable combination of catalytic cracking feed preparation and catalytic cracking processes is considered in this paper.

Vacuum flashing to high distillate yields, limited by metallic-contaminants carry-over, is shown to be attractive. Other feed-preparation processes effectively reduce the metallic-contaminants content of the distillate feed.

A simple combination of viscosity breaking and vacuum flashing of long residue, termed "flash cracking," is described and compared with solvent deasphalting of vacuum-flasher pitch and fluid coking. Solvent deasphalting produces distillates giving low coke makes in catalytic cracking; flash cracking is best from the standpoint of metals rejection. Flash cracking is somewhat more flexible and adaptable to changing market conditions because it can produce either No. 6 fuel oil or a small yield of unblended solid pitch.

It is concluded that the best pattern for future refinery construction is to reduce gradually production of No. 6 fuel oil and to maintain relatively high gasoline yield by combining deep feed preparation — such as flash cracking — with two-stage catalytic cracking. This combination makes maximum use of a catalytic cracking process operated in its most effective manner.

PROCESSES — SECOND SESSION

Presiding: Frederick Powell, vice president and director, Standard Oil Company of California, Western Operations, Inc., San Francisco, California.

[*Session developed by F. C. Moriarty, Aurora Gasoline Company, Detroit, Michigan.*]

Improvement of Catalytic Cracking Feedstocks by Hydrogenation.

M. D. Abbott,† R. C. Archibald, and R. W. Dorn, Shell Development Company, Emeryville, California.

Hydrotreating of catalytic cracking feedstocks not only reduces sulfur and nitrogen contents of the oil, but, under suitable conditions, converts a large proportion of the condensed polyaromatic compounds to monoaromatics. Since polyaromatics nuclei crack only with great difficulty and then give rise to excessive coke, while monoaromatics lead to aromatic gasoline components, hydrogenation of catalytic cracker feed benefits both yield structure and product distribution in catalytic cracking.

An added benefit of hydrogenation is removal of metallic contaminants in the oil which tend to deactivate cracking catalysts. In commercial operation accumulation of these metals has had no deleterious effect on the hydrogenation catalyst.

Capital and operating costs of hydrogenating catalytic cracking feed vary with capacity, operating pressure, required space velocity, and construction standards. Required pressure and space velocity will, in turn, vary with feed properties. In general, capital costs are in the range of $100 to $200 per daily barrel of capacity; direct operating cost, which includes utilities, labor, maintenance, and catalyst, is normally less than 10 cents per barrel of feed.

Laboratory and pilot-plant catalytic cracking of a variety of hydrogenated feedstocks indicates that coke yields are decreased by as much as 65 percent and gasoline yields increased by up to 20 percent as a result of hydrogenation. At the same time, sulfur and nitrogen are reduced to low levels, and the octane numbers of the gasoline are improved.

Commercial operations by Shell Oil Company of Canada, Limited, have given results in good agreement with the laboratory data.

Commercial Unifining of Distillates and Gas Oils.

C. F. Gerald† and L. O. Stine, Universal Oil Products Company, Des Plaines, Illinois.

Increasing numbers of refiners are using Unifining to upgrade various refined stocks and to improve results in further processing steps. A wide variety of commercial operations confirm results previously predicted by laboratory and pilot plant investigations.

Stocks other than naphthas successfully Unifined in commercial installations include kerosines, burning oils, diesel fuels and distillates from coking and thermal cracking, as well as virgin gas oils. Representative data from these operations are presented and discussed.

Principal benefits include desulfurization, improved color and storage stability, and better odor. Net effect is increased customer acceptance and improved competitive position.

Unifining of catalytic cracking feed stocks — virgin atmospheric and vacuum gas oils and likewise coker gas oils — shows good benefits in products quality. Sulfur contents are reduced and leaded octane ratings of cracked gasolines increased. Conradson Carbon and heavy metals content also are reduced, with resulting savings in catalyst cost.

Prepared Discussion: Unifining — Some Operating Cost Information.

W. J. Baral, L. R. Damskey Jr., and G. W. Hendricks, Union Oil Company of California, Los Angeles, California.

Union Oil Company of California has developed operating cost information for the Unifining process from its own operations and those of others. Of particular interest is the low catalyst cost.

Both operating cost and investment data are given.

Houdry Dehydrogenation for Olefin Production.

Lee Friedman, D. E. Womeldorph,† and D. H. Stevenson, Houdry Process Corporation, Philadelphia, Pennsylvania.

Expansion of national synthetic rubber capacity by private industry, following government "decontrol" of the industry and disposal of government-built facilities, has brought about an increase of approximately 400,000 tons in national annual butadiene capacity.

Approximately two-fifths of this expansion was accomplished by increasing the capacity of existing facilities. More than 60 percent of the new butadiene capacity, or 250,000 tons annually, is accounted for by six entirely new plants, all of which were first placed in commercial operation during 1957.

All the new plants use the Houdry Dehydrogenation Process. This process was developed during World War II to make butadiene for the mounting requirements of the synthetic rubber industry.

The authors describe the Houdry fixed-bed, multi-reactor, single-step process, which employs a chromia-alumina catalyst to convert normal butane to butadiene (for SBR, synthetic textile fibers, paint and petrochemical applications), to butenes (for aviation alkylate), or to produce both products concurrently in desired ratios.

Material balances are given for commercial operation for production of butadiene and butenes as single end-products, and for dual-purpose production, together with pilot plant runs showing close correlation with commercial results.

Laboratory data also are given for production of isoprene, isobutene, propylene, and styrene from appropriate charge stocks.

FUELS SESSION

Presiding: A. L. Lyman, president and director, California Research Corporation, San Francisco, California.

[Session developed by J. F. Socolofsky, Socony Mobil Oil Company, Paulsboro, New Jersey.]

The Role of Physical Factors in Knock

E. B. Rifkin, Ethyl Corporation, Detroit, Michigan.

Among physical factors significant in processes leading to knock and antiknock action, most important are time, temperature, pressure, surface area, and diffusion.

Importance of time, temperature and pressure is easy to see, since occurrence or nonoccurrence of knock is determined by outcome of a race between advancing flame front and reactivity of the fuel-air mixture.

Octane number is a measure of time that a fuel, mixed with air, can withstand given temperatures and pressures without self-igniting. Recent studies in the MIT rapid-compression machine show how time and octane numbers are related. An increase of one octane number in primary reference fuel series corresponds to an increase of about 1.3 percent in length of time before its mixture with air will self-ignite when exposed to high temperature and pressure.

Physical factors also affect antiknock action. To suppress knock, metal-organic fuel additives must first break down into discrete particles of metal oxide. This is controlled by temperature and time. Specially-designed engine tests show that no anti-knock action takes place when the fuel knocks before the metal-organic compound decomposes. In normal engine operation, temperatures are high enough to decompose metal-organic antiknocks.

Import factors controlling antiknock action include size of metal-oxide particles (which determines the surface area per unit of additive), composition of particle surfaces, and ability of reactive substances in fuel-air mix to reach these surfaces (diffusion). Studies of antiknock decomposition have shown that particles vary widely in size but are often smaller than one-millionth of an inch. Indication is that specific chemical changes occur when the particles interact with the fuel and air. Precombustion reactions play an important role, because they can change form of the metal oxide. The varying effectiveness of metal-organic antiknocks in different fuels may someday be explained on the basis of particle structure and their changes.

These same principles can be applied to the problem of antiknock antagonism. It can be shown, for example, that active sulfur compounds in fuel react with fine oxide particles from antiknock and convert them to sulfates. Ability of an antagonist to reduce antiknock effectiveness is closely related to its thermal stability, as can be seen by comparing literature data on the stability of these compounds with antagonism data obtained from knock ratings.

Studies of Chemical Reactions Which Occur In an Engine Prior to Knock.

K. J. Pipenberg, A. J. Pahnke and R. H. Blaker,† E. I. du Pont de Nemours and Co., Wilmington, Delaware.

Complex chemical reactions in unburned fuel-air mix ahead of flame front in a spark-ignition engine can lead to autoignition of remaining mix. Rapid rate of energy release accompanying this explosive combustion is responsible for knock.

Considerable progress in understanding causes of knock has come from systematic study of chemical reactions which occur prior to autoignition. This study has involved identification of major reaction products formed before autoignition to develop a picture of overall course of the reactions.

Direct chemical analysis of fuel-air mixes which have undergone preknock reactions has been widely used to establish reaction products identity. Recently, a spectrometer has been used to follow composition changes of reacting fuel in the engine combustion chamber as pressure and temperature conditions which produce knock are approached, thus providing means for studying preknock reactions as they occur.

Chemical reaction between unburned fuel and air which takes place in the unburned mixture prior to knock 1, releases heat and thereby increases temperature and pressure of unburned charge; 2, results in formation of new chemical species, some more stable and others less stable than original fuel molecules; and, 3, results in formation of highly reactive free radicals which are critical reactants in autoignition. Relative importance of each of the previous factors in the overall knock process varies with hydrocarbon structure and engine conditions.

Initial preflame oxidation of paraffin hydrocarbons leads to organic peroxides, unsaturates, and higher carbonyl compounds and is followed by formation of hydrogen peroxide, formaldehyde, and carbon monoxide. Excited modecules are also formed which give rise to cool flame and blue flame radiation. As autoignition is approached, concentration of reactive free radicals appears to increase, caused in part by decomposition of organic peroxides. Reactions involving these reactive radicals, chain-branching in nature, are involved in the autoignition process.

TEL is relatively ineffective in inhibiting early preflame reactions which result in the formation of such well-defined oxidation products as peroxides, aldehydes, and ketones. However, it is extremely effective in inhibiting the critical free-radical reactions which cause autoignition.

In contrast, aromatic and olefinic blending components

increase octane ratings in a different manner. Aromatics have a chemical structure sufficiently resistant to oxidation so that they act as inert diluents during preknock reactions of blends. Olefins have a chemical structure which seems to make them inhibit many of the early preknock reactions which would otherwise lead to autoignition.

Knock Characteristics of Hydrocarbon Mixtures.

Eric J. Y. Scott, chairman — blending subcommittee, API Research Project 45, Paulsboro, New Jersey

API Research Project 45 has made substantial contributions toward determining knock ratings of pure hydrocarbons in the gasoline boiling range. However, detailed information of this nature does not give unequivocal values for knock ratings of hydrocarbon blends. Thus octane number of a blend cannot always be computed by adding octane numbers of blend components in proportion to relative concentrations.

In 1954 a special committee of Research Project 45 was formed to study the fundamental principles of blending with a view to eventually establishing means for predicting knock ratings of hydrocarbon mixtures. Approximately one dozen companies have cooperated over the past four years by contributing hydrocarbons or by rating blends.

The severity of engine conditions, used for rating a fuel, has been recognized as an important complicating factor. Thus, in this program, interaction at various severity levels has been studied. Interaction — manifested as a positive or negative deviation from linearity — has been shown to be a common phenomenon. This paper reports results of the studies and indicates some conclusions concerning effects on interaction of severity level, hydrocarbon class, and antiknock compounds.

Many of the curves observed have well-defined characteristics. A preliminary attempt has been made to rationalize these features in terms of a hypothetical model based on physicochemical principles.

Behavior of Blends of Pure Hydrocarbons in Cool Flames as Related to Their Deviations from Linear Blending on the Performance Number Scale.

[A prepared discussion on Dr. Scott's paper.]

C. E. Boord, J. M. Derfer,† M. L. Smith, H. R. Menapace, and G. Kyryacos, The State University, Columbus, Ohio

It has been pointed out by Dr. Scott that precombustion reactions have an important influence on the knocking characteristics of hydrocarbon fuels.

In conjunction with the blending studies discussed by Dr. Scott, we currently have underway a preliminary study of the cool-flame behavior of selected mixtures of some pure hydrocarbons. Analysis of partial combustion products and of hydrocarbon and oxygen consumed is being carried out by gas chromatography.

Studies made with a specially equipped CFR test engine have yielded valuable information.[3] They show that cool-flame reactions taking place in a motored engine do not differ qualitatively from those taking place in a cool-flame tube, and indicated that substantial chemical interactions occur in combustion of blends of hydrocarbons. It appears that these interactions not only affect the relative rates of oxidation of the components, but also produce major changes in the preflame product mix.

Also, precombustion products from a motored engine operating without ignition are identical in kind with those obtained before the flame front from the same engine with spark ignition. Mixtures of *iso*octane and n-heptane showed more preflame reaction than predicted from the tests on the individual hydrocarbons.

Amounts of precombustion products for a number of binary mixtures under comparable conditions in the motored engine were found to be inversely proportional to the knock resistance of the mixtures: Positively deviating mixtures gave low yields of these products, and negatively deviating ones gave high yields. The correlation was roughly quantitative.

PIPING SESSION

Presiding: Clay Thompson, manager of manufacturing, Mohawk refinery, Mohawk Petroleum Corporation, Bakersfield, California.

[*Session developed by J. P. Mooney, Humble Oil & Refining Co., Baytown, Texas.*]

Influence of Prolonged Service at Elevated Temperatures and Pressures on High-Temperature Strength of Chromium-Molybdenum Alloy Tubing.

John F. Ewing, The Babcock & Wilcox Co., Beaver Falls, Pennsylvania

Influence of prolonged refinery service at elevated temperatures and pressures on high-temperature strength was evaluated for 5 Cr-½ Mo and 9 Cr-1 Mo heat-resistant alloy tubing. Creep-rupture tests at 1100 F, supplemented by room-temperature tensile, impact, flattening, and hardness testing, together with metallographic studies, were made on both 5 Cr-½ Mo and 9 Cr-1 Mo furnace tubes retired from service after operating periods ranging up to 116,640 hours. Both longitudinal coupon and tubular creep-rupture tests were made on 5 Cr-½ Mo tubing. Longitudinal and transverse strip creep-rupture tests were run on a 9 Cr-1 Mo furnace tube retired from high-temperature service.

Several important conclusions can be made:

1. Extensive creep-rupture testing at 1100 F of longitudinal coupon specimens cut from walls of four 5 Cr-½ Mo furnace tubes retired from refinery service after operating times ranging from 44,000 hours to 115,000 hours over 1100 F metal temperatures shows no evidence of decreased high-temperature strength or ductility.

2. Tubular creep-rupture tests at 1100 F on a 5 Cr-½ Mo furnace tube after 116,640 hours over 1100 F show no decrease in strength when principal test stress in the wall is computed assuming thin wall conditions.

3. These tubular creep-rupture specimens displayed good ductility at rupture indicating no high-temperature embrittlement from prior service.

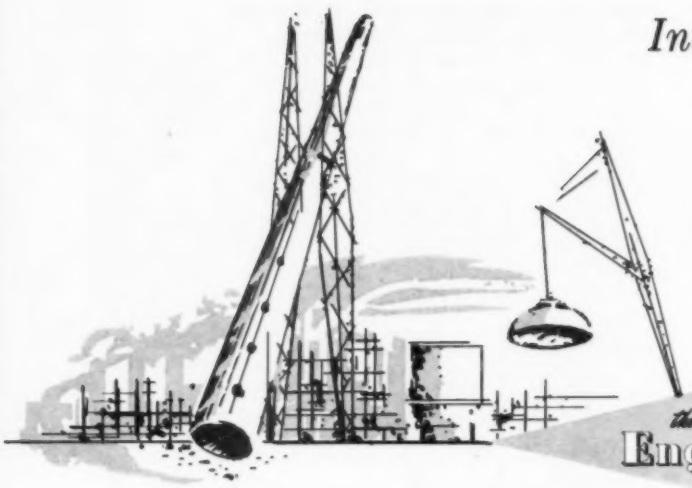
4. There were no significant differences in transverse and longitudinal creep-rupture strengths at 1100 F of a 9 Cr-1 Mo tube after retirement from service. Both strengths agreed fairly well with average published strengths for annealed 9 Cr-1 Mo.

5. Both transverse and longitudinal rupture ductility were good and indicated adequate ductility at high temperature.

6. Room-temperature strength and ductility of 5 Cr-½ Mo and 9 Cr-1 Mo tubing as measured by tensile, impact, and flattening tests, were not decreased significantly by prolonged exposure to elevated temperatures.

7. Metallographic studies revealed good structural sta-

(Continued on page C-59.)



Introducing the . . .

REFINERY CONSTRUCTION MANUAL

the Refining Engineer

Part 1: Initial Considerations . . .

. . . Why build a new refinery?
. . . Where should it be located?
. . . What capacity would be best?

Henry Martyn Noel
Norwalk, Connecticut

How does one decide when and where to build a new refinery?

Usually, refineries are built to meet a demand for products, and are located either near the center of the market, or near the source of crude. However, there are many other factors that influence choice of refinery location, such as transportation pattern, political atmosphere and possible government interference, import taxes, labor market, and strategic considerations.

Once a general area is selected, there are the more specific problems of land cost; soil bearing values; fresh and salt water availability; electric power, railroads, docks and highways; local taxes, and many other local conditions.

General Refinery Location

The Marketing Department, reaching for more sales, is often the first to broach the subject of a new refinery.

A large potential or new market otherwise to be supplied at exorbitant transportation cost is most apt to suggest a new refinery located closer to the market.

The new refinery is usually justified by (1) saving transportation costs from existing remote refineries, and (2) anticipation of a rapidly growing market.

Source of crude oil. In general, other things being equal, it is best to build near the source of the crude oil.

An average refinery burns and loses 6 to 10 percent of its crude supply as refinery fuel and waste. Thus, by refining near the crude source, and shipping only products, a worthwhile reduction is made in transportation costs — compared to refining at a point remote from the oil fields.

Transportation costs. Large tankers are the cheapest method of crude transport. Pipelines generally are more expensive than water transport, except for the more costly use of small barges on inland waters.

Railroad transport is the most expensive method—except for highway tank trucking, which is used only for short hauls of finished products.

Middle East crude, priced at $2.10 per bbl at Ras Tanura, Saudi Arabia, costs about $1 per bbl for transport to refineries in Europe 5000 miles away. This is 20 cents per 1000 bbl miles, including the Suez Canal toll.

A standard T-2 tanker (16,750 dead weight tons, 14.5 knots) can carry an average cargo of 105,000 to 120,000 bbl, depending on the length of the trip. Allowing for repairs, turnarounds, and no return cargo, it will move an average of 3500 bbl per day annually when in a 10,000-mile round trip service, or 5900 bbl per day annually in a 5000-mile round trip service. The newer large supertankers show even more favorable capacity, of course.

By comparison, transport of gasoline in 5000 gal tank trucks (from refineries to bulk or service stations 50 miles away) costs about 40 times the T-2 tanker rate, or 40-cents per bbl — $8 per 1000 bbl miles.

Large pipelines can handle crude for 20 cents per 1000 bbl miles, while small lines can handle finished products for 80 cents per 1000 bbl miles.

Railroad transport costs, subject to Interstate Commerce Commission regulations, average $2 per 1000 bbl miles.

Political atmosphere. In countries other than the United States, government decrees are often the basis for new refinery construction — and in time of war, this can be true in the United States.

In countries such as France and Italy, where existing sales quotas could be withdrawn from companies failing to build, new refineries are sometimes built to avoid losing existing business—not make new profits. This same coercion is often applied by preferential import taxes.

The world's largest refinery, from crude throughput standpoint, is on a barren coral island where drinking water is imported in tankers. The island site was picked because it was under the control of the stable and friendly Dutch government.

A more logical refinery location would have been on the Venezuelan mainland close to the fields of the world's cheapest crude oil — except that an unpredictable dictator *at that time* made investment in Venezuela too risky.

Specific Site Selection

Waterways. Water transport advantages usually place refineries on or near waterways. This means special considerations of docking facilities, water pollution, channel dredging and fire protection.

All of these problems must be settled with local authorities, and firm understandings and agreements reached.

Water supplies. Need for cooling water for refinery operations, portable water for personnel, and pure water for boilers requires a careful initial study of the water situation.

Twice as much cooling water will be needed if its temperature is 85 F instead of 60 F. In some locations cooling towers can reduce the cooling water demand; in others high humidity makes cooling towers ineffective.

Water may have well below the usual allowable 15 ppm of silt, or it may have 200 to 300 ppm silt and become a major obstacle.

A simple 25,000 bbl per day refinery may need from 15 to 30-million gal per day cooling water, thus taking an impractical amount from the local populace — and giving it back unpotable and warm.

Air pollution. This is another factor that might make a new refinery unwelcome by the local populace. Prevailing winds, atmospheric inversion frequency, smog pocketing, cost of making sulfur from H_2S, and cost of scrubbing high-sulfur stack gases must be faced in selecting the new refinery site.

Local government attitude. Local regulations and attitudes must be analyzed — as they affect both operation and construction.

Should working permits be obtained for all foreign personnel, must local unemployed be used, are health and sanitation rules strange or unusual? Must local materials be used for certain construction, are building codes peculiar and restrictive, must local customs officials and inspectors be housed, are certain foods or drinks unobtainable? Must a certain percentage of locally hired supervisors be used, are there ample welders, firebrick masons, and other specialized workmen? All these points must be studied for the report on whether or not to build.

Other local conditions. Items applying to specific localities are condition of public transport facilities, water, sewer, power supply, and labor market. Difficulties in getting highway, railroad, telephone, and electrical connections must be studied.

Also to be considered in early estimates are soil bearing values, wind velocities, earthquake and flood possibilities, and sources of road and fill material.

How Big a Refinery?

Refinery size for any given location is determined by the market it will serve, which in turn is fixed by the relative costs and convenience of the refinery products to the customer, compared to his alternate sources of product supply. Thus, refinery location and size are often joint problems.

Capacities for the more than 700 oil refineries in the world range from a few hundred up to several hundred thousand barrels per day. While overall average capacity of a little more than 20,000 bbl per day, about two-thirds of the world's refineries run less than 10,000. Some 35 refineries have capacities of more than 10,000 bbl per day.

The most rudimentary refinery (a skimming plant which simply boils some gasoline out of crude, selling the rest as fuel oil) to handle 10,000 bbl per day crude could be built for as little as $1-million in 1955.

A complete 10,000 bbl per day refinery making aviation and motor gasoline, kerosine, diesel fuels, heating oils, lube oils, bunker fuel, asphalts, and propane would cost about $20-million. However, such complex refineries are not built with so small a capacity.

In recent years, the trend has been rapid toward larger refinery units. Market demands are met with large single units instead of numerous smaller ones. For example, in 1934 the average French refinery was 10,000 bbl per day, but in 1954, it was 30,000 bbl per day. England and The Netherlands now have refineries of over 100,000 bbl per day capacities — unheard of before the last war. Tidewater Oil's new 130,000 bbl per day, $200,000,000 plant in Delaware has only one unit for each operation — unheard of in large, older refineries.

Reason for larger units is that, per barrel of crude, smaller units cost more to build and operate. Competition is so keen that the extra operating costs for small units may be greater than profits from larger units.

While an *efficient*, simple refinery in the U. S. might process crude for 70 cents per bbl, a small refinery can easily spend more than a dollar. Also, the large operator can install expensive yield or quality improvement processes, again putting the small operator at a disadvantage.

A small refinery is usually simple because expensive, specialized aromatics extraction or alkylation equipment is hard to justify in small capacity.

The marketing department must vouch for a continued market for the new refinery's products. Also, marketing must specify market size and quality needs.

Intentions and capabilities of competitors must be anticipated by marketing as well as possible. And too, what effects on quality or price would be imposed by a new source of supply?

Is the market to be served by the refinery healthy and growing — or is it subject to sudden blight?

Meet Henry Martyn Noel, author of *The Refinery Construction Manual*.

Mr. Noel *is a veteran in refinery planning, construction and operation, having 31 years experience with Standard Oil Company (New Jersey) and its affiliates. Recently retired, one of the highlights of his career with Esso was managership of construction and initial operation of that company's first large refinery in France.*

Following graduation from Iowa State College, Mr. Noel served the A.E.F. during World War I and was awarded the Distinguished Service Cross. He had quite important and taxing duties during World War II as a member of the Joint Bomb Target Committee in London and later Bucharest.

His construction and operating experience then led him to be placed on General Douglas MacArthur's staff in Tokyo to inspect all bombed Japanese refineries and to set quotas for their initial operation after rehabilitation.

Mr. Noel now resides at Silvermine, Norwalk, Connecticut. He is a member of the American Chemical Society, Sigma Xi, and the Far Eastern Ceramic Group.

***The Refining Engineer's Refinery Construction Manual* is an 18-chapter series covering all phases of new plant design, planning, engineering, purchasing and procurement, fabrication, construction and operation.**

Additionally, the concluding chapters will present valuable tips on how to rapidly increase capacity by bottleneck removal, conversion of units, etc.

We sincerely commend this outstanding new series to process and mechanical engineers along with management, as an important guide to planning and control.

This is another RE "first" to clip and file for your engineering-construction-maintenance notebook! — ***The Editors***

Catalytic cracker "grows" at Tidewater's East Coast refinery.

Photo courtesy Tidewater Oil Company

Preliminary Studies

Early in the study of a new refinery project, the question of product quality arises. Current and long range specifications must be determined for each proposed product and equipment designed to meet these specifications with reasonable assurance that such design will suffice for a period of years. In other words, it must be fairly certain that the proposed refinery equipment will not be obsolete before it has paid for itself.

Preliminary estimates, prepared for a variety of alternative operating methods are made, often for several proposed sites. As each is submitted and studied, modifications and improvements will be suggested and more estimates made.

This series of reviews of preliminary schemes often covers dozens of alternative cases, and takes many months.

The Economics Department meanwhile supplies figures on revenue to be expected from the various preliminary schemes, and comparison of estimated construction costs.

Even if the project shows the usual minimum 10 percent annual return, after taxes, upon new money needed for the new refinery — construction may or may not be justified, depending upon what other projects and obligations the company has.

Other departments will also have their say, including the Public Relations Department, Legal, the Comptroller, and perhaps foreign exchange specialists.

The Marketing Department has duties other than the aforementioned market size and quality analyses. It must estimate the cost of advertising, sales promotion, and expanded marketing facilities that may be involved in a refinery production somewhat out of balance with current demand.

Too much heavy fuel oil is a frequent Marketing Department problem. If it fights the glut of residual fuel bitterly enough, engineers will have to make an estimate or two that includes coking in certain of the alternative refinery design proposals.

Management Approval

Whether the new refinery is justified by a new tax condition, a new crude source, a new market opening, an arbitrary government decree, or the need to replace old and inefficient equipment, innumerable questions must be answered by the Board of Directors.

Often directors are well-split into "pro" and "con" groups, thinking up reasons for and against the proposed refinery. Some of the questions they may ask are:

- Why hasn't anyone else built there?
- What is the total demand in the area?
- What is our percentage of the demand?
- What profits have we been making there?
- Who says there'll be a big expansion?
- Can we export what we can't sell locally?
- What would the laid-in crude cost be?
- What's our tanker position to handle it?
- What's the processing cost per barrel in such a refinery?
- What could we do with the excess residuum?
- Can we get our dollars out of the country?
- Is there assurance against a new tax?
- How could our competitors kill the refinery profits?
- How long will the crude supply last?
- What does the realization sheet show?
- How will you make 60 percent gasoline from that crude?
- What's the cost of lead in the gasoline?
- Has anybody asked the Governor what he thinks?
- What do the local unions say?
- Are spares for contemplated shutdowns included?
- Is there any flexibility in the design?
- How are the contractors fixed for work now?
- Would we be held up for pipe, vessels, switchgear?
- Can we get the money out of local funds?
- Who would run the job?
- Can we get any remission of tax on profits?
- Would this cut the delivered gasoline cost in other markets?
- Should we make lubes?
- Will the government start fixing prices there?
- What depreciation rate can we get?
- Couldn't we handle a larger fuel oil sales area?
- How about return cargo for crude tankers?
- Can we get good general publicity?
- What would the additional publicity and sales campaign cost?
- Would there be a public relations angle in locally refined products?
- Aren't steel and labor costs too high to build now?
- How much would this increase our share of the local business?

These questions in Executive Committee meetings are apt to go on for years as the preliminary study proceeds. Normally, two years will elapse before the staff engineers, economists, and estimators cover all angles and wear down the opposition.

Extended trips by several engineers and long specialized studies by the marketers and transportation men will be needed. The tax experts and treasurer will figure several alternative financing schemes.

Finally, based on a process flow plan, a yield chart, and a comprehensive realization sheet with an attached cost estimate, the new refinery is approved in principle. This date of actual authorization from the Big Board may be called "D-Day" — from it elapsed time until completion is impatiently measured.

Next Month in *The Refinery Construction Manual*:
"Preliminary Engineering of a New Refinery" will discuss planning, estimating, scheduling, procurement, etc., along with engineering manpower requirements.

PERMEATION...

A New Commercial Separation Tool

Otherwise unfeasible operations are possible with this new process... liquid solubility and molecular structure are the criteria for separation

Robert C. Binning
and
Frank E. James
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FOR SOME YEARS, American Oil Company has been investigating permeation as a means for separating liquid mixtures. This has led to development of a general separation technique which should find application in both petroleum refinery and chemical plant problems.

How it works. Permeation is a physical method of separating mixtures by use of thin plastic films or membranes. The membranes are nonporous; they contain no holes or pores and function neither by molecular sieving action nor by Graham-type diffusion through holes. Instead, permeation requires solubility of material in the polymer comprising the membrane, movement of material through the polymer structure by an activated diffusion process and finally, removal of material in the vapor phase from the opposite side of the membrane. Choice of membrane material depends upon the nature of the mixture being separated. Separation of components occurs because one component is preferentially soluble in the membrane.

A schematic diagram of the permeation operation is shown in Fig. 2. The unit is divided into two compartments by the membrane. Charge mixture, which is illustrated as a 50-50 mixture of black and white molecules, is introduced into the left-hand compartment. The charge is maintained in the liquid phase at the temperature of operation, requiring charge pressure to be atmospheric or whatever the vapor pressure of the mixture is at the operating temperature. The right-hand side is maintained at a lower pressure so that the permeate is vaporized. As shown, the white molecules preferentially pass through the membrane. In the example

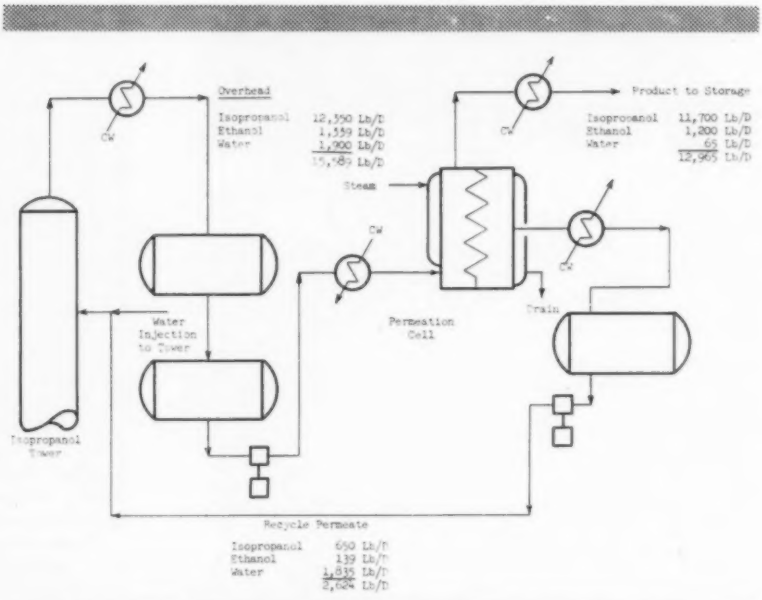


FIG. 1. Flow plan and balance for dehydrating mixed alcohol by membrane permeation.

shown, the product or permeate contains about 80 percent white molecules. This is typical of many systems where a one-stage permeation unit separates an 80-90 percent pure material from a 50-50 mixture.

Process applications. Permeation is particularly useful as a separation method whenever simple distillation is either of no benefit or requires extensive equipment (number of plates). Just as differences in boiling point or vapor pressure are criteria for estimating difficulty of separation in distillation, solubility and molecular structure are the criteria in permeation.

The membrane permeation process has been found useful for separating wide varieties of liquid mixtures. Close boiling mixtures, azeotropic mixtures, and even wide boiling mixtures can be separated. Hydrocarbon mixtures such as petroleum fractions can be processed to recover aromatics, to separate hydrocarbon isomers, to improve octane number of gasoline boiling range fractions, and to otherwise refine or concentrate such mixtures. It also may be considered as a replacement for certain solvent extraction operations.

Equipment design. The simplicity of equipment needed for permeation is the primary reason for its favorable economic comparison. Major piece of equipment is, of course, the film holder. Means must be provided for

supplying heat of vaporization; this can usually be done by jacketing the film holder. In some cases, a moderately reduced pressure in the permeate zone may be required to remove the vapor phase permeate.

Operating variables. Important variables in either rate or selectivity are film composition and thickness, temperature, and pressure. Both rate and selectivity are primarily controlled by the choice of film. Choice depends on the nature of the mixture, and experimental work is generally needed to guarantee a proper film selection. A typical film might resemble cellophane wrap on cigarettes in respect to thickness and toughness.

Extensive knowledge has been acquired on the effects of film composition, film thickness, operating temperatures, pressures, etc. Troublesome problems of film rupturing, maintenance of film stability, permeation rate and selectivity have been explored and solved from start-up of the process to termination of the run. Continuous operations for extended periods of time have been carried out.

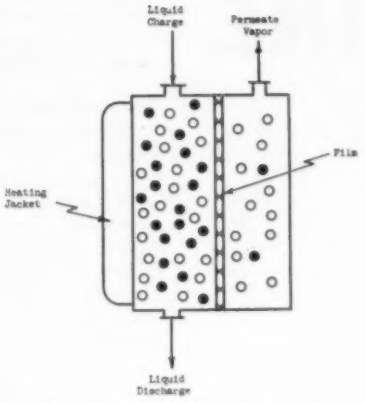


FIG. 2. Diagram of the permeation separation technique.

TABLE 1. Cost Comparison for Isopropanol Drying Processes.

	Membrane Permeation	Hexane Azeotroping
Investment for New Equipment	$76,000	$100,000
Operating Costs, $/Year @ 85% Service Factor		
1. Labor, ¼ Operator @ $3/Hr	6,570	6,570
2. Supervision @ 15% of (1)	990	990
3. Maintenance Labor @ 2.5% of Inv	1,900	2,500
4. Labor Benefits @ 20% of (1), (2), (3)	1,890	2,010
5. Maintenance Materials @ 1.5% of Inv	1,140	1,500
6. Hexane Loss @ $0.17/Gal	—	470
7. Membrane Replacement @ $2/Film Unit	220	—
8. Utilities	740	1,620
9. Gen and Admin Overhead @ 50% of (1), (2), (3), (4), (5)	6,240	6,780
10. Property Taxes and Ins. @ 1.5% of Inv	1.140	1,500
Annual Cost, $/Year	$20,830	$23,940
Unit Cost, ¢/Lb	0.64	0.74
Capital Costs, $/Year		
Cost for 5-year payout, after income taxes plus depreciation[1]	$23,400	$30,800
Total Capital and Operating Costs		
Annual Cost, $/Year	44,230	54,740
Unit Cost, ¢/Lb[2]	1.36	1.68

1. Depreciation rate @ 10% per annum, income tax @ 52%.
2. Based on 10,470 lb/SD of crude i-PrON feed (dry basis).

Example — ternary azeotrope separation. Process design for a commercial installation charging 15,600 lb per day of a ternary azeotrope has been made. A simplified flow diagram is shown in Fig. 1. The application here illustrates the simplicity and, as will be discussed later, the economic advantage of permeation over the best alternate scheme.

Here, a ternary azeotrope of isopropanol, ethanol, and water is an overhead product from a distillation tower. This stream, as produced, has little or no market value because of the water content. However, mixed alcohols containing a maximum of 0.5 percent water are salable. Permeation equipment was proposed which would selectively remove a water-rich material from the ternary azeotrope and reduce the water content in the alcohols to 0.5 percent or less. As an alternate to permeation, a two-tower azeotropic distillation scheme using hexane for the entrainer was proposed.

As shown in Fig. 1, the ternary overhead product is preheating and charged to the permeation cell. Water-rich permeate is returned to the water injection point of the tower, therefore eliminating any loss of alcohols which permeate with the water. Ethanol-isopropanol mixture not passing through the film is sent to product storage.

Film area of the permeation cell is about 650 sq ft. A steam jacket around the cell supplies the heat of vaporization for the permeate. Films are precut and mounted for support and to facilitate ease of placement in the cell. The cell, with its auxiliary equipment, would fit into a space about 8 ft long, 6 ft wide, and 6 ft high.

Film stability and support. Of primary interest to operating personnel is reliability or stability of the films and down time required for changing them. Certainly, operating with and handling these films which are only about 1/1000 of an inch thick would appear to be good reason to doubt their practical application. The films themselves are tough (several months operation has been achieved), and will withstand abuse except for pricks by sharp or pointed objects. They are supported to enable withstanding pressure difference during operation. Placing the films in the cell is comparable to positioning stiff paper in a filter press. In the particular design described above, a surge tank to hold 48 hours of charge was included. Actually, changing the films should be accomplished easily in a unit this size in one 8-hour shift.

Comparative economics. Table 1 shows comparative economics of membrane permeation versus azeotropic distillation with hexane. Estimated investment for azeotropic distillation equipment is 31 percent greater than for the permeation equipment. Annual operating costs are also 15 to 16 percent greater for azeotropic distillation. Capital costs would, of course, be less for permeation because of the lower investment. But, the real difference between the two alternates is in the cost per pound of marketable alcohol — about 20 percent less for permeation.

Main advantage is selectivity. The liquid permeation process shows excellent characteristics as a general separation method. Rapid rates of permeation and the simplicity of design attainable by this method of operation, along with the excellent selectivities observed, give this process good commercial potential. Principal advantage lies in its unique selectivity, unlike that of any process presently in use. Process design and economic evaluation of one application has already proved its attractiveness.

It now appears that many applications will be feasible in separation of azeotropes, mixtures of organic chemicals, and mixtures of hydrocarbons which cannot be separated by conventional means. ★ ★ ★

MODERN GASOLINE PLANTS

. . . A Series on Economics, Design, Equipment and Operations

Dave Vondy
Constructive Engineering Company, New Orleans, Louisiana

Part 2. Cold Absorption Plants for Liquids Recovery

LOWER OPERATING TEMPERATURES are becoming more and more common for gasoline plant absorption facilities. In fact, absorption temperatures ranging from zero to 20 F are not at all uncommon for recently installed plants. And, under favorable conditions even lower temperatures have been found practical.

Low temperature operations require, despite obvious advantages, special considerations in design and present a number of operating problems that must be taken into account in choosing the best plant design.

This chapter discusses cold absorption plants, presenting important facets of their economics, design and operation.

Why Use Cold Absorption?

Lower temperatures permit higher recoveries in the absorption process. This is illustrated in Fig. 10, which shows typical overall recovery as a function of absorption oil rate and temperature.

Since equilibrium constants are lower, a given amount of oil will remove more liquids from the gas stream at lower operating temperatures. Or, at a given rate of recovery, less oil is required at lower temperatures. Further, pre-cooling of the gas entering the plant will knock out some liquids, thus reducing absorption load.

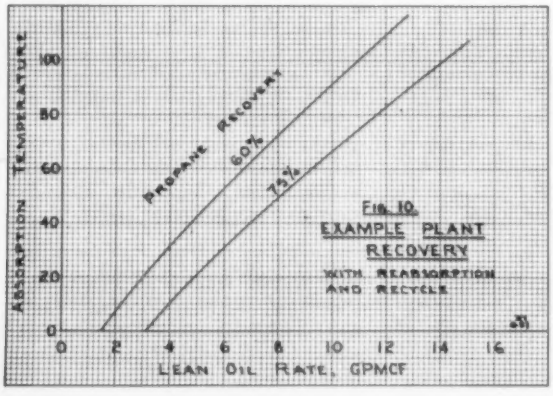


Fig. 10. EXAMPLE PLANT RECOVERY WITH REABSORPTION AND RECYCLE

To take full advantage of the reduced temperature obtained by refrigeration, absorption should be carried out at or near this temperature. In other terms, it would be unwise to permit the heat of absorption to carry the actual operating temperature too far above the temperature of the incoming gas and oil streams.

Temperature rise can be controlled by proper selection of the means for applying the refrigeration.

Practical Methods for Refrigerating an Absorber

One of the more practical techniques for refrigerating an absorber is shown in Fig. 11. Top and bottom of the tower are used primarily for heat exchange, whereby existing cold gas at the top of the tower is reheated by entering lean oil and cold rich oil leaving the bottom of the tower is reheated by entering rich gas. Product streams are thus reheated to near normal temperatures while the absorber is operated at reduced temperature.

This general method can be best applied to existing plants by circulating sidestreams through external coolers. Unless the oil rate is quite high, however, adequate heat transfer will not be obtained and a more elaborate heat exchange system may be warranted.

There are, of course, many ways to apply refrigeration to a cold absorption plant involving various combinations of chilling rich gas and lean oil, intermediate cooling of oil by pumparound streams, and hot and cold stream heat transfer. All combinations should be investigated to find which would be best in a given situation. Many of these are discussed later.

Lean Oil Flow and Processing

Amount of absorption effected is a function of the number of moles of oil contacting gas. The lower the molecular weight of the oil, the more moles per unit volume. Consequently, the lighter the oil, the lower the volumetric circulation required to obtain the same absorption.

For example, contacting gas with 0.4 mol per Mcf to effect approximately the same absorption would require 7 gal per Mcf of 100 M.W. oil, 9 gal per Mcf of 150 M.W. oil, 11.5 gal per Mcf of 200 M.W. oil, or 12 gal per Mcf of 250 M.W. oil. It is evident, therefore, that the lowest practical oil weight will result in the lowest installed plant cost and lowest operating cost since oil circulation rate is minimized.

Oil which will be circulated in a low temperature plant

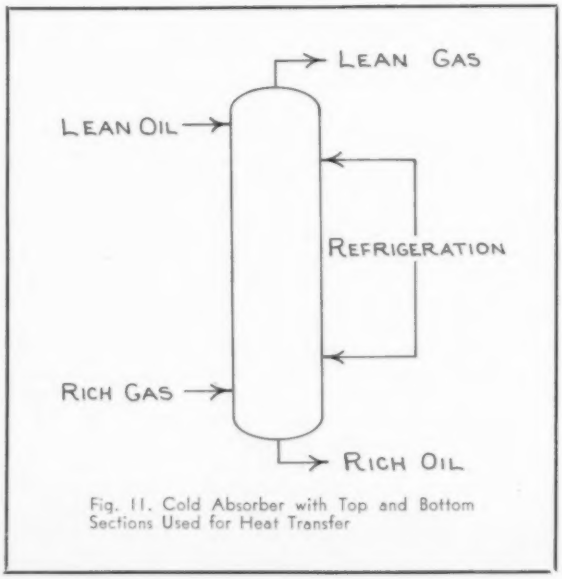


Fig. 11. Cold Absorber with Top and Bottom Sections Used for Heat Transfer

will generally be the accumulation of the heaviest fraction in the rich gas entering the plant, regardless of the initial lean oil charge. It follows, of course, that if raw liquids were charged to the plant, oil would be the heaviest fraction in the liquids.

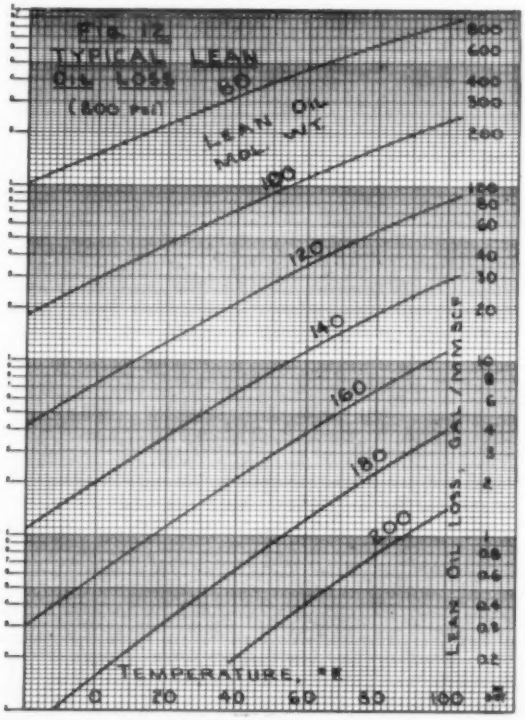
Operation with a select oil could be accomplished by distilling or stripping it from heavy ends. However, this is not often practical because of the large heat and cooling loads required. But, it may be necessary to draw a sidestream of lean oil from the stripper and continuously remove a portion of the heaviest fraction from this stream by stripping off the light oil, thus maintaining a practical equilibrium molecular weight.

Another alternative would be to take a "sloppy" cut between lean oil and gasoline, thus removing a portion of the lean oil as product — if end point of the gasoline is not increased above specification. Or, a cut might be taken into the gasoline and a portion of the lean oil continuously removed as a separate product and/or blended into gasoline.

It should be pointed out, though, that removal of the heaviest fraction from gasoline will usually reduce plant income. This fraction will "hold" a considerable amount of the lightest component normally sold with the gasoline to meet specification vapor pressure. Therefore, considerable attention should be given to the way this heavy fraction is handled.

Loss of lean oil to lean gas increases with decrease in the molecular weight of the oil, as illustrated in Fig. 12. The loss decreases, of course, with decrease in the final contact or separation temperature (which may be the top tray temperature in the absorber). But, even at low temperatures this loss should be determined and steps taken to reduce it to a practical minimum.

Three methods commonly used for applying refrigeration to reduce lean oil loss, especially when a light oil is used, are shown in Fig. 13. Considerable heat is generated when the oil makes initial contact with gas; it is therefore often desirable to saturate the oil and cool it before it is charged to the absorber.



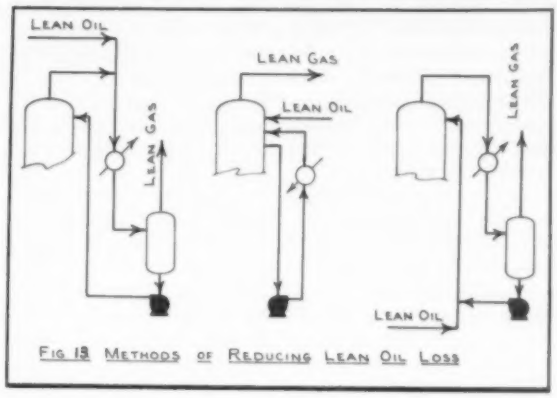


FIG 13 METHODS OF REDUCING LEAN OIL LOSS

Loss of lean oil due to liquid particle entrainment can be significant. This can be minimized with a mist extractor, such as one made from wire mesh. Baffle plates are sometimes used. When wire mesh is used, it must be remembered that the element may be structurally weak, especially if plugging by hydrates or other solids is possible. Accordingly, a protective device might be installed to automatically bypass the element in the event of excessive pressure drop, thus avoiding expensive down-time for repair.

Rich Oil Flow and Processing

Use of a light oil enables products to be removed from rich oil by fractionation rather than by steam stripping. This can eliminate need for steam generating facilities and their attendent operating problems such as make-up water treating, corrosion, etc. Also, products are water-free if steam stripping is not required — usually an advantage in storage, transportation and sale. Further, the lean oil will be dry, permitting its use at lower operating temperatures without special dehydration.

Solution gas in the rich oil should be minimized for a number of reasons: To reduce compression load, to reduce losses to this gas when it is removed from the rich oil, and to simplify processing in the fractionation section.

Amount of solution gas in the rich oil is a function of bottom temperature in the absorber. The lower that temperature, the more gas that will be in solution. Amount of solution gas is especially significant in cold absorption plants.

One method by which the amount of solution gas is minimized was shown in Fig. 11, where the rich oil was heated by the incoming rich gas. Fig. 14 shows how heat can be applied from an outside source to remove solution gases.

Demethanization or deethanization may be carried out in the bottom of the absorber in certain situations. Limiting condition is the maximum pressure at which the two phases exist — this pressure for deethanized rich oil is often around 600 psi, making it impractical to deethanize above 500 psi. Limiting pressure of the demethanized rich oil is somewhat higher, values depending on composition and properties of the lean oil.

It should be noted that as the limiting pressure is approached, the bubble point temperatures rise rapidly, equilibrium constants converge, and the densities of the liquid and equilibrium vapor approach a common value which could cause separation problems.

Design for a Small Plant

Flow in a small plant is shown in Fig. 15. Rich gas is cooled by water, then by cold lean gas, finally by a refrigerant, then fed to the absorber. Liquid is drawn from the side

of the absorber at a suitable point, cooled by refrigerant, and returned to the tray above point of removal. This scheme enables circulation of a larger amount of oil than flows down the column and uses two trays for heat transfer.

Rich oil is heated in cooling the lean oil and is fed to the deethanizer. Fractionation equipment would be provided as required, with all heat supplied by recirculated lean oil heated in a single heater.

Tail gas from the deethanizer would contain a considerable amount of recoverable fractions. Thus it would usually be passed through a reabsorber, be refrigerated to recover liquids, or be recompressed and recycled.

Water in the rich oil, if any, will be stripped out by the vapors in the deethanizer. Minimum temperature to which the tail gas can be cooled without hydrate trouble depends, therefore, on the water content of the rich oil.

Most of the heat exchangers, including those at the bottom of the deethanizer, would be designed for countercurrent fluid flow to gain maximum heat transfer and also to reduce to a minimum the required difference of energy level between the fluids. In any situation, the actual heat loads and heat available in various streams must be examined to determine the most economical scheme of heating.

Lean oil is produced here from the stripping column by simple fractionation from the gasoline, without a stripping gas.

Cold Absorption in a Large Plant

Application of refrigeration in a large plant is shown in Fig. 16. Rich gas is cooled by water, with a portion also cooled by cold, lean gas and fed to the absorber a few trays from the bottom. Free liquids and remaining gas are fed to the bottom of the column.

Lean oil is pumped into lean gas leaving the top of the absorber, the combined streams cooled and separated. Lean oil is then pumped to the top of the absorber.

Rich oil is heated by a hot lean oil stream and fed to the top of the absorption section of a deethanizer-reabsorber. A system of regenerative heat exchange is shown for the reabsorber section, by which a low absorption temperature is possible with a minimum of refrigeration. Heat is supplied to the reabsorber from hot lean oil or some other medium.

By dividing the rich gas into two streams, sufficient heat can be transferred to the lean gas to return it to near atmospheric conditions while the remainder is used to heat rich oil to reduce solution gases. Refrigeration is thus applied in a way to make it most effective.

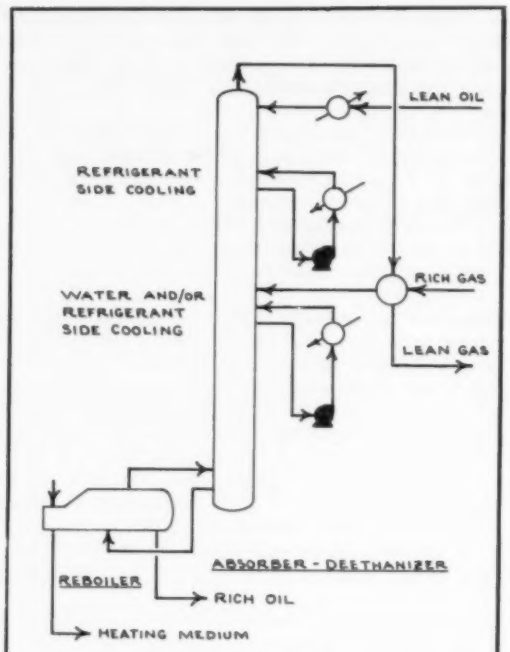


FIG. 14 ABSORBER-DEETHANIZER

Application of Refrigeration

Application of refrigeration is one of the most important design considerations in a cold absorption plant. Many ways that it could be applied to some apparent advantage are not really economical. For example, propane recovery can be increased in any plant where a deethanizer is refluxed by cooling of overhead gas with water and the tail gas not recycled. While refrigerant rather than water in the reflux-condenser would increase recovery, recovery is not usually increased enough to justify the added system.

As mentioned earlier, cold streams should usually be brought to near ambient temperature before leaving the cold area of a plant. Also, the difference in energy level between the two fluids should be kept to a minimum when heat is transferred between them. In refrigeration, economic approach temperature is usually not more than 10 F.

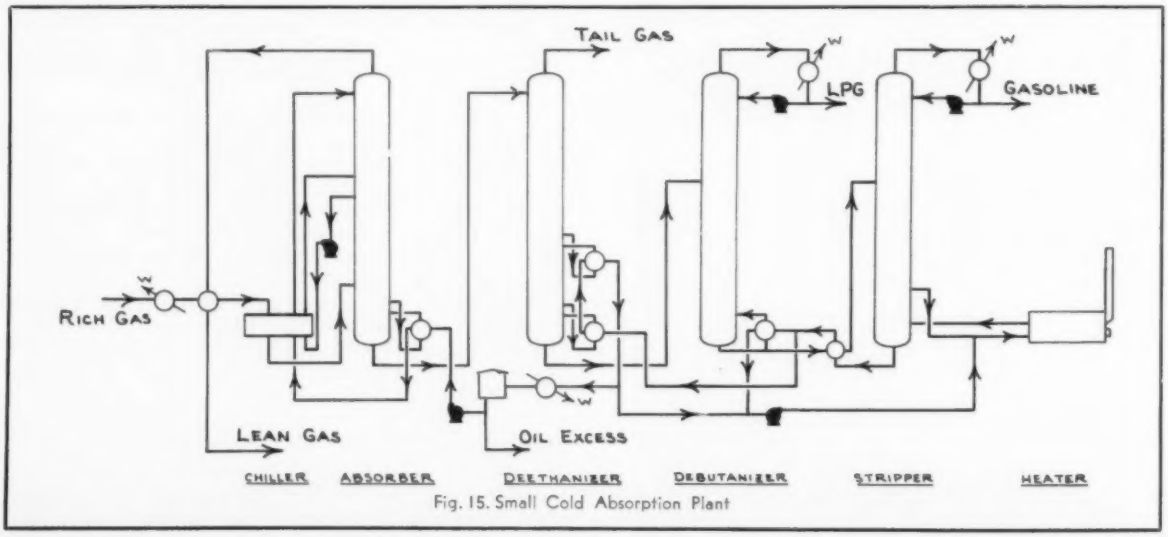


Fig. 15. Small Cold Absorption Plant

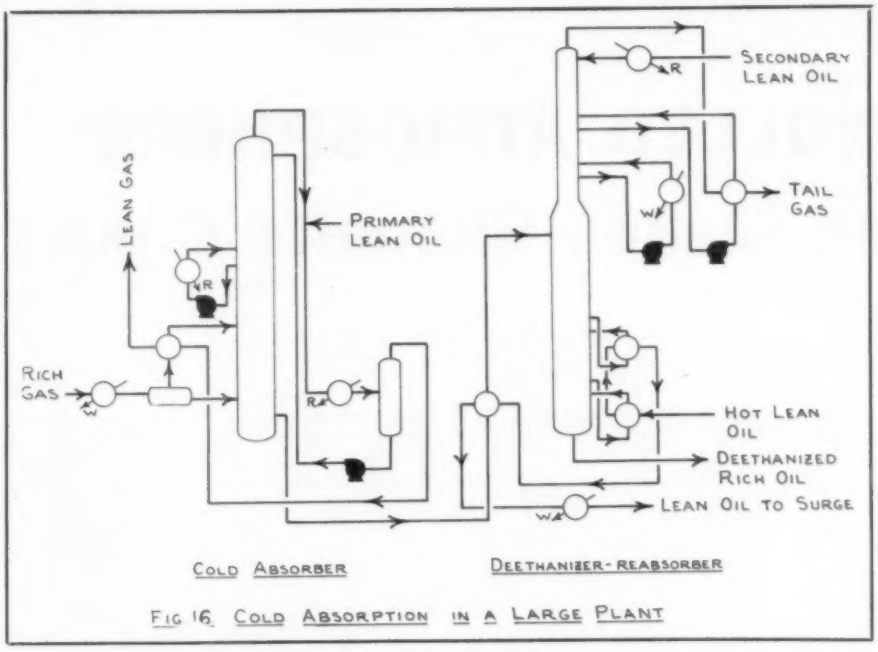


FIG 16 COLD ABSORPTION IN A LARGE PLANT

Heat balance for the cold section of a plant is shown below:

Load	Btu/mol rich gas	Tons of Refrigeration 50 MMcf plant
Saturated lean oil	50	20
Cool and condense products	780	360
Cool and condense light fractions	170	80
Cool lean oil	300	140
Cool lean gas	600	270
Gross cooling load (sub total)	1900	870
Heat transfer to lean gas	(530)	(240)
Heat transfer to rich oil	(520)	(240)
Regenerative heat exchange (sub total)	(1050)	(480)
Net refrigeration load	850	390

This heat balance points out the importance of transferring as much heat as possible to the rich oil by regenerative exchange. In the example, had the rich oil and lean oil been passed through an exchanger without additional recovery of refrigeration from the rich oil, net refrigeration load would have been increased to about 500 tons — nearly 30 percent increase.

Avoiding Hydrate Trouble

Low temperatures usually cause hydrate problems unless preventive steps are taken. Solid desiccant adsorption or glycol absorption can be used ahead of the plant or glycol injected into rich gas to inhibit hydrate formation. If lean oil must be dehydrated, such as in plants where steam stripping is used, gas stripping is probably the best water removal technique.

That a reliable system of dehydration or injection be used almost goes without saying. Certain standby equipment is usually justified, such as a spare pump, to be automatically placed into service should an operating component fail.

Special equipment may also be justified to avoid trouble. For example, if wet gas is supplied through a long flow line, a heater might be installed at the plant entrance to prevent hydrates from coming in during cold weather. Or, if a plant is on a pipeline carrying dry gas, automatic equipment could be installed to raise the temperature in the event of high water content.

Paraffin Wax

If the heavy fraction of the stream to be processed contains paraffin that will solidify, this stream cannot be cooled below its cloud point. Low temperature operation would be out of the question.

When a separation occurs between gas and distillate or oil, however, the paraffin will remain in the liquid under most normal conditions. Thus it is possible to separate the paraffin-containing liquid from the gas and process the gas at low temperature.

Market conditions often dictate that a heavy end fraction be processed for removal of the gasoline or to enable blending after light fractions have been removed. Since paraffin must be kept out of the fractionation system (otherwise it could get into lean oil), low temperature operation might be precluded. Fig. 16 illustrates a practical method of handling a gas containing a fraction that can not be cooled and if the lean oil is to be fractionated from a heavy end product. Using this technique, the paraffin-containing liquid can be handled in the fractionation system without concern that the wax will contaminate lean oil.

Keep Lean Oil Clean

Foreign material in the plant feed stream, products of internal corrosion, coke produced by cracking in the heater, or build-up of small amounts of paraffin can cause trouble. To avoid these problems, a small stream of lean oil can be withdrawn in much the same manner that a cooling tower or boiler are blown down, or the lean oil replaced when badly contaminated. Filtering is desirable to reduce pump wear and to prevent any heavy material from entering the pumps.

Pumping Cold Liquids

Pumping of cold liquids presents no particular problem if service requirements are taken into account when selecting pumping equipment. Care should be taken to insure satisfaction of pump NPSH requirements.

Steel at Low Temperatures

Design codes limit use of carbon steel to above –20 F. At lower temperatures, toughness and ductility decrease rapidly, creating hazardous conditions. Further, high stresses at notches caused by corrosion, thermal conditions or surface defects are aggravated at low temperatures. Alloys such as 18-8, which are free from embrittling, are therefore generally used for low temperature equipment.

Sweating

Low temperature equipment is usually wet due to condensation of moisture from the atmosphere. Care should be taken in selection of paint, coating and insulation to meet this service requirement. Magnesia insulation, for example, is not considered acceptable at low temperatures.

EDITOR'S NOTE: The next chapter of "Modern Gasoline Plants," to discuss conventional absorption, will be in the July issue of *The Refining Engineer*.

First of its kind . . .

'CONTROLLED ATMOSPHERE' Calcining Makes Gilsonite Coke

G. M. Fekula and C. H. Case
Kaiser Engineers, Oakland, California

THE FIRST INTEGRATED "controlled atmosphere" coke calcining unit was built for American Gilsonite Company, jointly owned by Standard Oil Company of California and Barber Oil Company, at their Grand Junction, Colorado, refinery. The unit produces electrode-grade calcined coke for the aluminum industry. Process design was developed from laboratory and engineering studies performed by several other organizations and coordinated by American Gilsonite Company.

A unique feature of this unit is integration of the calcining kiln, the calcined coke cooler and a kiln gas waste heat boiler to allow positive control of combustion atmosphere in the kiln and of pressures within the overall unit. Effectiveness of the integrated calcining unit to produce high yields has been proved in actual operation since startup in July 1957. Coke yields range from 8 to 15 percent above those reported for calciners of conventional design.

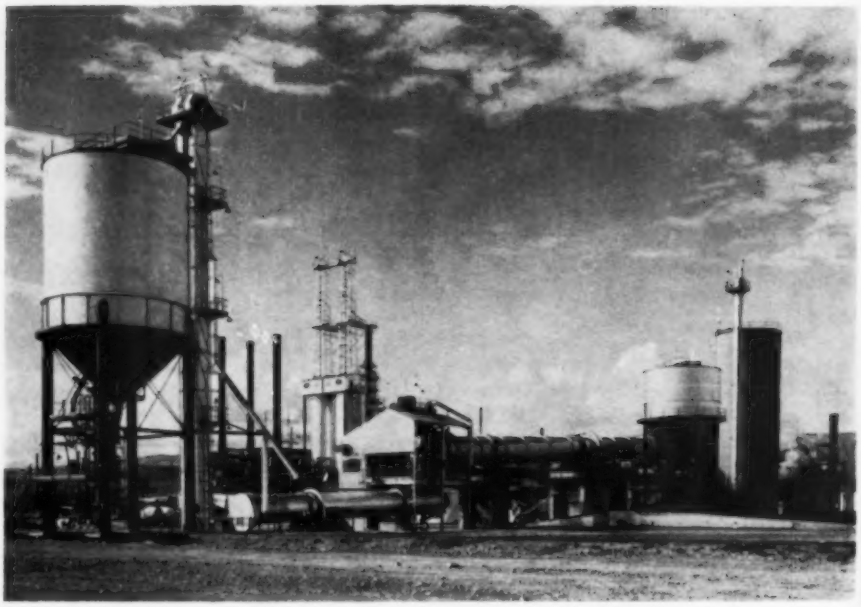


FIG. 1. Gilsonite coke calcining facilities, Grand Junction, Colorado.

Plant Description

The overall calcining plant was designed for 350 tons per day (dry basis) of green coke feed, but the calcining section was designed for 550 tons per day to allow for future expansion. Green coke from a conventional delayed coker is dewatered and transported by belt conveyors and a bucket elevator to a storage vessel. From here storage is conveyed to the kiln over a conveyor scale which continuously measures feed weight.

Coke slowly gravitates through the 10-ft diam, 185 ft-long kiln, which revolves at about 1 rpm. A single specially designed burner in the hood at the discharge end of the kiln provides most of the heat for calcining and permits control of flame configuration on either oil or gas fuel. Close combustion control permits addition of heat from burning of cracked gases emanating from the coke bed with minimum burning of the coke itself. An air blower provides primary and secondary air to the burner assembly; each is individually controlled.

Hot calcined coke temperature is 2300 to 2500 F at the end of the kiln. From the kiln it drops through a chute into an 8-ft diam, 80-ft long rotating cooler. Impinging jets of water cool hot coke within the slowly-turning drum. Water rate is carefully controlled so that coke is cooled in an atmosphere of superheated steam, preventing any moisture in final product. Cooled coke drops out of the cooler to the product conveyor scale and then to an elevator to lift product into a storage vessel. A cyclone removes fines from cooler exhaust gas by water washing; fines slurry is pumped back into the cooler inlet to provide part of the cooling water. A blower exhausts clean gas to atmosphere.

Hot kiln gases leaving at the coke inlet end pass through a settling chamber designed to remove most of the entrained coke fines. This chamber is divided into three sections for progressive elutriation. Fines fall into a bin located at the bottom of each section. This permits selective recirculation of fines which are returned to the kiln via an elevator and chute, bypassing the conveyor scale. Fines from the third bin are now discarded.

Gas from the settling chamber passes into two parallel waste heat boilers. Use of two boilers rather than one was dictated by refinery steam requirements, met solely by these boilers. Separate burner assemblies are provided in each boiler for the kiln gas and for auxiliary oil or gas fuel, and are designed for boiler operation at full rated capacity when the kiln is not operating. Kiln gas burners are specially designed to handle low-Btu gas containing coke fines.

Calciner Has Two Functions

One function of a calciner is to eliminate moisture and reduce volatile combustible matter (VCM) in green coke. The water content of green coke

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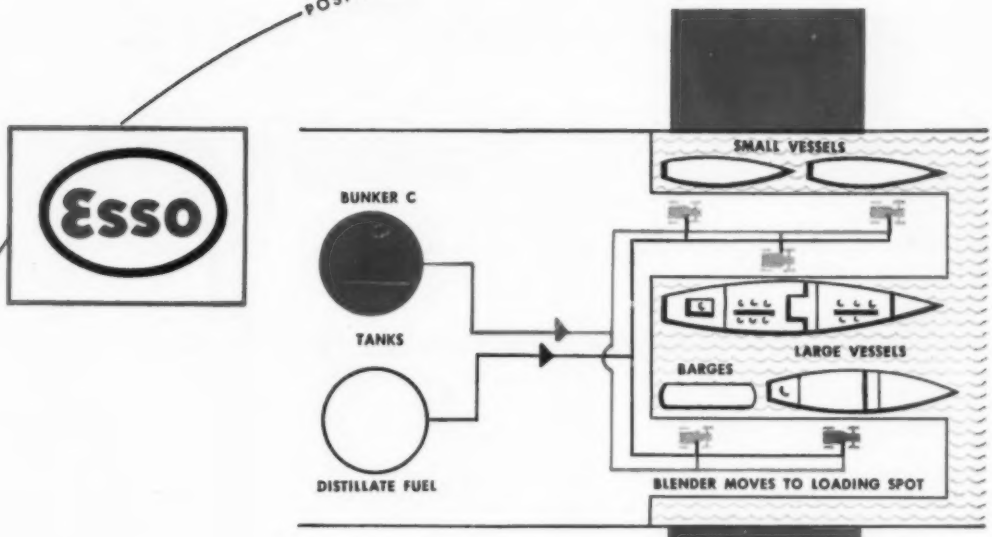

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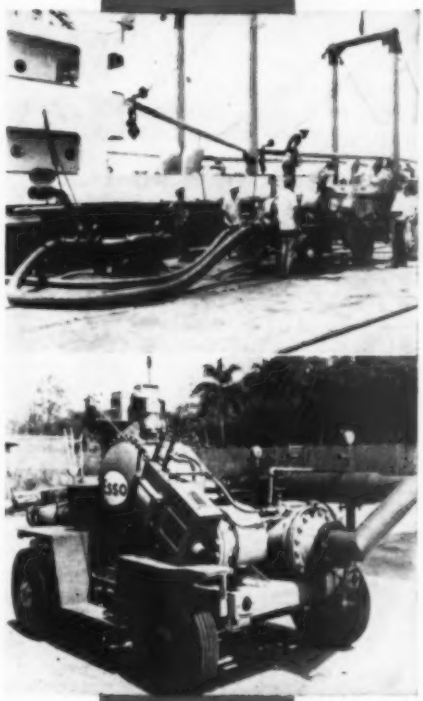

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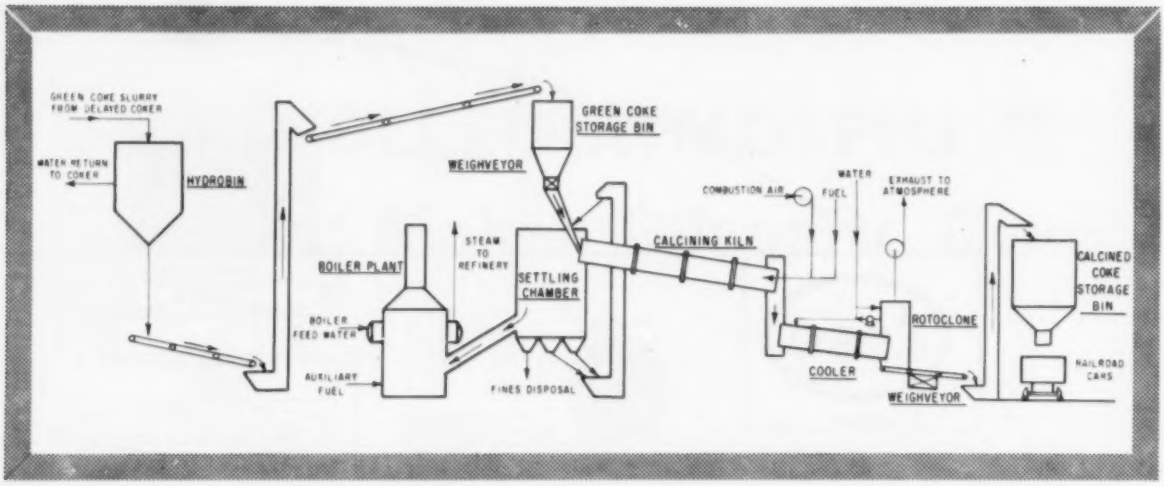

FIG. 2. Flow scheme for integrated coke calciner-cooler-boiler.

received from the hydraulic decoking system may range from 6 to as high as 15 percent, depending on physical characteristics of the coke and amount of draining. VCM can be considered as heavy oil that remains on green coke after the steaming operation in the delayed coking unit drums. VCM content of green coke may range from 11 to 14 percent, depending on coking unit operation. It must be reduced to 0.5 percent or less to be acceptable for electrode manufacture.

The other calciner function is to produce coke with a physical structure that permits manufacture of electrodes which will perform satisfactorily under severe conditions of operation in aluminum reduction furnaces.[2] Physical structure is indicated indirectly by real density measurement of the calcined coke, but proper interpretation of this test requires correlation with actual plant performance for the particular type of coke used.

Because of close control of kiln combustion air, kiln gas to the boilers contains appreciable combustible gases produced by thermal cracking of VCM in the colder section of the kiln. The relatively high heating value of this "waste gas" is an extra advantage resulting from the closed system and contributes to effectiveness of the kiln gas boiler.

Operating Results

The Gilsonite calciner is designed and instrumented for positive combustion air control and control of pressures at important points in the integrated kiln-cooler-boiler unit. To prevent uncontrolled air leakage into the unit, air seals are provided at necessary points. Overall result is a high degree of flexibility in operation which provides for control of kiln temperature, optimum regulation of primary and secondary air, and high calcined coke yield and overall high thermal efficiency.

TABLE 1. Representative Properties Gilsonite Green and Calcined Coke.

	Green Coke	Calcined Coke
Volatile Combustible Matter	13.0%	0.15%
Moisture	1.0%	0.10%
Fixed Carbon	85.7%	98.70%
Ash	0.3%	0.45%
Sulfur	—	0.20%
Silicon	—	0.05%
Iron	—	0.03%
Titanium	—	0.008%
Nickel	—	0.03%
Vanadium	—	0.0008%
Real Density	—	2.03 g/cc
Resistivity	—	0.035 ohms/in³
Screen Analysis		
Plus 4 Mesh	—	20.0%±
Plus 8 Mesh	—	40.0%±
Plus 14 Mesh	—	57.0%±
Plus 28 Mesh	—	87.0%±
Plus 100 Mesh	—	99.0%±

Calcined coke yields to date have averaged 85 percent (adjusted to moisture-free feed and product). Properties of representative plant samples of green and calcined coke are given in Table 1. These data give evidence that yield from a controlled atmosphere calciner is 8 to 15 percent greater than yields reported from conventional-design coke calciners that make commercially acceptable product.

Part of this increased yield is attributed to reduction in burning of calcined coke. Kiln fuel substituted for the reduction in coke burned costs less than one-third as much as calcined coke.

Another part of the improved yield is due to favorable temperature gradient within the kiln. This is conducive to coking of the volatile combustible matter prior to its escape from coke. In effect, the unit approaches being a high temperature coker for VCM, utilizing direct contact heat exchange.

The overall American Gilsonite Company development has been previously reported.[1] Total investment for mining, pipelining and processing Gilsonite was approximately $16,000,000 for production of 1300 bbl per day gasoline, 300 bbl per day fuel oil and 250 tons per day calcined coke. Manufacture of high quality coke contributes substantially to profitability of this project. High coke yield together with fuel economies from integration of a waste heat boiler contributes to reducing payout of this investment.

References

1. "Gasoline from Mineral Ore!," *The Refining Engineer* 29, No. 14, E-19, September 1957.
2. Martin, S. W., and Nelson, H. W., "Carbon Materials Required in Electrolytic Reduction of Alumina," *Journal of Metals* 7, No. 4, 540-3, April 1955.

★ ★ ★

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Fig. 1793 — Large Iron Body Bronze Mounted Gate Valve for 125 W. S. P. Outside screw rising stem and yoke, solid wedge disc. 8" and larger valves can be supplied with split wedge disc. Also available in all iron.

Fig. 559 — Large High Test Iron Body Bronze Mounted Swing Check Valve for 125 W. S. P. Heavily bolted iron cap. Renewable bronze seat rings, discs or disc facing, disc hinges. Can be used in horizontal or vertical position. All iron valves also available.

Fig. 1503 — Steel Gate Valve for 150 pounds. Outside screw rising stem. Heavily bolted bonnet and yoke. Precision fitted, accurately guided solid wedge disc. Valves with welding ends can also be supplied.

Fig. 1460 — "Master Pilot" Gate Valve for 150 W. S. P. Iron body bronze mounted. Bolted flanged bonnet with inside screw rising stem, solid wedge disc. Can also be furnished with flanged ends, and in all iron.

Fig. 8150 — Bronze L. P. Gas Globe Valve for 400 W. O. G. Union bonnet, inside screw rising stem, special composition disc, integral seat. Listed by Underwriters' Laboratories, Inc. Angle, Gate, Lift Check and Steel Valves available.

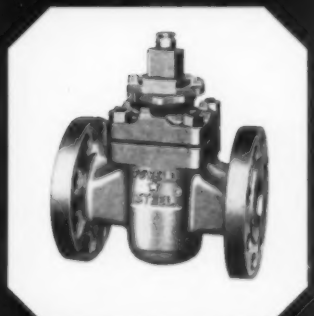

Fig. 1559 — Steel Lubricated Plug Valve for 200 pounds W. O. G.—A. S. A. 150 pounds. Screwed gland type. Single gland and bolted gland types can also be furnished. Large Valves—6" and above, can be supplied with gears for gear operation.

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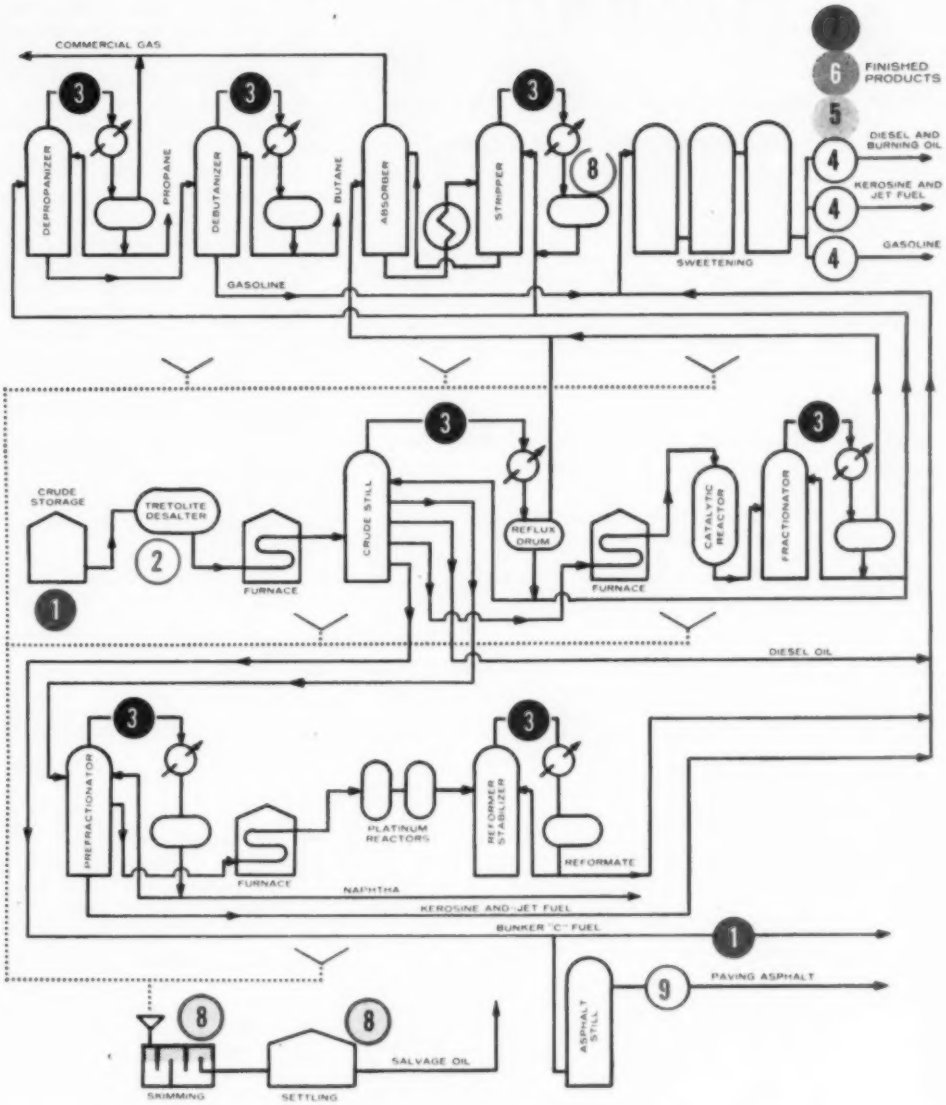

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AR-58-2

CALCULATE PIPE STRESSES EFFICIENTLY

Part 2: Calculation of Moments and Torques; Determination of Signs

K. Hao Hsiao
Pasadena, California

The tabulation, computation and determination of signs in Table 2 are entirely an "automatic" procedure. The values of forces (X,Y,Z), the coordinates of points on the system (x,y,z) and the centroidal coordinates of the system ($\bar{x}$,$\bar{y}$,$\bar{z}$) are first filled in Table 2. The relative moment values on rows (1), (2), (3), (4), (5), and (6) are calculated. Then the signs of these relative moments for the first point "a" on the system are determined (explained in next paragraph). After that, the signs of moments for the remaining points are "automatically" and instantly determined from the first point. For instance, in Table 2 of Example 1, since the sign of the value on row (1) for point "a" is the same as that of $y-\bar{y}$, the signs of *all* the remaining values on row (1) are the same as those of the coordinates above them.[1] Similarly, since the sign on row (2) for point "a" is opposite to that of $x-\bar{x}$, the signs of *all* the remaining values on row (2) are opposite to those of the coordinates above them.[2] The same rule applies to rows (3), (4), (5), and (6). Thus, only the signs of moment values for point "a" need be determined. All the remaining signs in the entire Table 2 can be instantly filled in without thinking.

The signs of the relative values on rows (1) to (6) for point "a" are determined as follows: As shown in Fig. 1, the X-Y plane is parallel to paper, and the Z-axis is perpendicular to paper. The analyst should view X-Y plane by looking down at the paper, X-Z plane from top of paper and Y-Z plane from right side of paper. Then, open the right palm, and point the thumb in the direction of a force and the remaining fingers in the direction of centroidal distance of a point in the piping system (end or joint), i.e., the direction of coordinate $x-\bar{x}$, $y-\bar{y}$, or $z-\bar{z}$ in Table 2. If the palm is toward the analyst, the moment or torque is negative. If the back of the hand is toward the analyst, it is a positive value.

For instance, in Table 2 of Example 1 for point "a" in X-Y plane, since the sign of $y-\bar{y}$ is negative (-4.67 ft), point right thumb in the direction of X force and the remaining fingers in the direction of negative Y-axis. In this case, the palm of the right hand is toward the analyst so the relative moment $X'(y-\bar{y})$ is a negative value (-7.66).[1] Using the same rule, the relative moment $Y'(x-\bar{x})$ is also a negative value (-4.75).[2] The total relative moment M'_{xy} at point "a" is the algebraic sum of the two values or -12.41. When the force is a negative value, indicating its direction opposite to that assumed originally, the analyst should point the thumb in the same negative direction. In this way, positive signs of M'_{xy}, M'_{xz}, and M'_{yz} indicate clockwise direction, while negative signs, counterclockwise direction. If the analyst requires only numerical values of bending moment and torque, and not their directions, then $M'_{xy} = (1)-(2)$, $M'_{xz} = (3)-(4)$, $M'_{yz} = (5)-(6)$, where the signs of (1), (2), (3), (4), (5) and (6) agree with their respective coordinates. In this case, the column under heading "sign" may be ignored.

Although the positive direction of any one of the axes shown above may be reversed due to reversal of direction of expansion along that axis, it is convenient for the analyst to use the same notations for the axes, i.e., X and Y for axes in a plane parallel to paper.

Of the three moment values, two are bending and one, torsional. The greatest vector sum of the former, multiplied by the force Z, gives the maximum combined bending moment of the system, and the latter, multiplied by Z, gives the corresponding torque. In this case, the maximum combined bending moment is, by inspection, at point "d," i.e., 9640 ft-lb.

In Fig. 3, end "a" is assumed to be connected to a large-diameter header at the same temperature and anchored 3 ft 7 in. away from "a" in the direction of X-axis. Therefore, the total length for expansion in the system in the

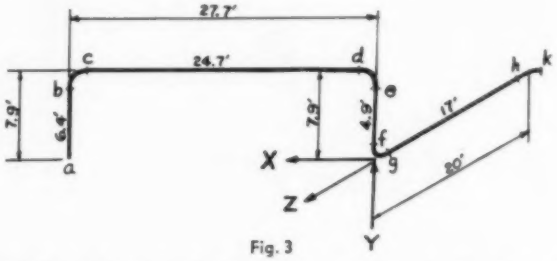


Fig. 3

				POINT	a	b	c	d	e	f	g	h	k
$X'=\frac{X}{Z}=1.64$				x	27.7	27.7	26.2	1.5	0	0	0	0	-1.5
$Y'=\frac{Y}{Z}=.254$				y	0	6.4	7.9	7.9	6.4	1.5	0	0	0
$Z'=1$				z	0	0	0	0	0	0	-1.5	-18.5	-20
XY	ROW	SIGN	$\bar{x}=8.97$	$x-\bar{x}$	18.73	18.73	17.23	-7.47	-8.97	-8.97	-8.97	-8.97	-10.47
			$\bar{y}=4.67$	$y-\bar{y}$	-4.67	1.73	3.23	3.23	1.73	-3.17	-4.67	-4.67	-4.67
	(1)	+		$X'(y-\bar{y})$	-7.66	2.84	5.30	5.30	2.84	-5.20	-7.66	-7.66	-7.66
	(2)	−		$Y'(x-\bar{x})$	-4.75	-4.75	-4.38	1.9	2.28	2.28	2.28	2.28	2.66
	(1)+(2)			M'_{xy}	-12.41	-1.91	0.92	7.2	5.12	-2.92	-5.38	-5.38	-5.00
XZ			$\bar{z}=-6.2$	$z-\bar{z}$	6.2	6.2	6.2	6.2	6.2	6.2	4.7	12.3	-13.8
	(3)	−		$X'(z-\bar{z})$	-10.2	-10.2	-10.2	-10.2	-10.2	-10.2	-7.71	20.2	22.6
	(4)	+	$\bar{x}=6.92$	$Z'(x-\bar{x})$	20.78	20.78	19.28	-5.92	-6.92	-6.92	-6.92	-6.92	-8.42
	(3)+(4)			M'_{xz}	10.58	10.58	9.08	-15.62	-17.12	-17.12	-14.63	13.28	14.18
YZ			$\bar{z}=3.73$	$z-\bar{z}$	3.73	3.73	3.73	3.73	3.73	3.73	2.23	-14.77	-16.27
	(5)	−		$Y'(z-\bar{z})$	-.95	-.95	-.95	-.95	-.95	-.95	-.57	3.75	4.13
	(6)	+	$\bar{y}=3.76$	$Z'(y-\bar{y})$	-3.76	2.64	4.14	4.14	2.64	-2.24	-3.76	-3.76	-3.76
	(5)+(6)			M'_{yz}	-4.71	1.69	3.19	3.19	1.69	-3.21	-4.33	-.01	0.37

MAX. MOMENT @ "d"

$M'_d = \sqrt{7.2^2 + 15.62^2} = 17.2$ $\quad M_d = 560(17.2) = 9640$ ft-lb.

$T'_d = 3.19$ $\quad T_d = 560(3.19) = 1788$ ft-lb.

AT "k"

$M_k = 560\sqrt{5^2 + 14.18^2} = 8400$ ft-lb. $\quad T_k = 560(0.37) = 207$ ft-lb.

Table 2.

[1]This is indicated by plus sign under heading "sign" in Table 2.
[2]This is indicated by minus sign under heading "sign."

X-direction is 31.3 ft and the expansion is $\Delta_x = .313(13.1) = 4.1$ in. The expansion in the Z-direction is $\Delta_z = .20(13.1) = 2.62$ in.

Hot and Cold Forces and Moments

The forces X, Y, and Z and moments and torques from Tables 1 and 2 are "ranges," from which their values in hot and cold conditions can be obtained. For instance, the X forces in hot and cold conditions are obtained from the following formulae:[3]

$$X_h = \left(1 - \frac{2}{3}c\right)\frac{E_h}{E_c}X$$

$$X_c = cX, \text{ or } X_c = \left(1 - \frac{s_h}{s_e}\frac{E_c}{E_h}\right)X \text{ where } \frac{s_h}{s_e}\frac{E_c}{E_h} < 1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

Assuming 50 percent cold spring or $c = 0.5$, we have:

$$X_h = \frac{2}{3}\left(\frac{21.6}{27.4}\right)919 = 484 \text{ lb}$$

$$X_c = \left(1 - \frac{6600}{25{,}150}\frac{27.4}{21.6}\right)919 = 613 \text{ lb.}$$

Equation 18 applies also to moments and torques from Table 2, changing X to M or T.

Pipe Stresses

The expansion stress s_e at any point in a system, based on E_c and full expansion, is defined in the Code:

$$s_e = \sqrt{s_b^2 + 4s_t^2}$$

$$s_b = \frac{iM}{S} \qquad s_t = \frac{T}{2S} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

where the stress intensification factor "i" is defined below for elbow, circular bend, mitre bend, with the condition that it is greater than unity.

$$i = \frac{0.9}{h^{2/3}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$

The maximum value of s_e or the controlling stress range shall not exceed the allowable stress range s_a, defined in the Code:

$$s_a = f(1.25\, s_c + 0.25\, s_h) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

For the effect of pressure and weight on expansion stress, the reader is referred to the Code. Assuming $f = 1$ and substantial pressure and weight stresses, we have, for the system in Fig. 3:

$$i = \frac{0.9}{(0.082)^{2/3}} = 4.77 \qquad s_b = \frac{4.77(9640)12}{22} = 25{,}100 \text{ psi}$$

$$s_t = \frac{1788(12)}{2(22)} = 488 \text{ psi}$$

$$s_e = \sqrt{25{,}100^2 + 4(488^2)} = 25{,}150 \text{ psi}$$

$$s_a = 1.25(18{,}750) + 0.25(6600) = 25{,}100 \text{ psi}$$

therefore, the system in Fig. 3 is not overstressed.

The procedure for computing force and moment ranges (Tables 1 and 2) and controlling stress range (Equation 19) on the basis of E_c and full expansion range is equivalent to computing the forces, moments, and stresses as if the line had been cold sprung 100 percent. These values represent the ranges or a conservative estimate of the sums of hot and cold forces, moments, and controlling stresses in the system. The exact values of these sums for different "c" factors are always greater than their respective ranges, thereby providing a margin of safety. For instance, for the force "X" and 50 percent cold spring, this margin is

$$X_h + X_c - X = \frac{2}{3}\left(\frac{21.6}{27.4}\right)X + \left[1 - \frac{6600}{25{,}150}\left(\frac{27.4}{21.6}\right)\right]X - X = 0.19X$$

The use of allowable stress range as the limit for controlling stress range, and the computation of maximum hot and cold forces and moments from their respective ranges, based on E_c and 100 percent expansion, are deduced from the phenomenon of "self-springing," resembling cold springing. (The relaxation of initially high stresses in the hot condition and the creation of reversed stresses in the cold condition.) This phenomenon is explained in Markl's paper.[4]

Allowable Limits

Assuming end "k" of the system in Fig. 3 to be at the nozzle of an equipment, the numerical values of hot and cold forces, moments and torques at "k" must be kept below allowable values, in order to avoid distortion of the equipment. Expressed in symbols, these values are X_h, X_c, Y_h, Y_c, Z_h, and Z_c obtained from X, Y, and Z of Table 1, and $(M_h)_k$, $(M_c)_k$, $(T_h)_k$, and $(T_c)_k$, obtained from M_k and T_k of Table 2, all by means of equations similar to Equation 18. Two sets of approximate allowable values have been suggested by Rossheim-Markl and Wolosewick in the absence of suitable manufacturer's data or applicable experience.[5] Pumps and turbines are especially sensitive to thrusts and distorting moments exerted by attached piping, so special care must be exercised in limiting the magnitudes of these reactions.

The maximum combined bending moment M_d in the system should also be kept within allowable limit, in order to prevent leakage at valves, flanges, and other joints. An alternative is to place these joints at points of low moment.

In addition to the above requirements, the piping engineer must see to it that the piping material is not overstressed beyond its allowable range at any point of the system. This is accomplished by keeping the value of s_e below s_a, as explained in the previous section.

To fulfill the above design requirements, the piping sys-

[3] 1955 ASA Code for Pressure Piping.

[4] Markl, A. R. C., "Piping Flexibility Analysis," *Trans.*, ASME, Vol. 77, No. 2, February 1955.

[5] M. W. Kellogg Company, "Design of Piping Systems," Second Edition, Table 3.5, Page 84.

D. B. Rossheim and A. R. C. Markl, "The Significance of, and Suggested Limits for, the Stress in Pipe Lines Due to the Combined Effects of Pressure and Expansion," *Trans.* ASME, Vol. 62, 1940, pp. 443.

F. E. Wolosewick, "Equipment Stresses Imposed by Piping," *Petroleum Refiner*, August 1950, pp. 89-91.

ABOUT THE AUTHOR

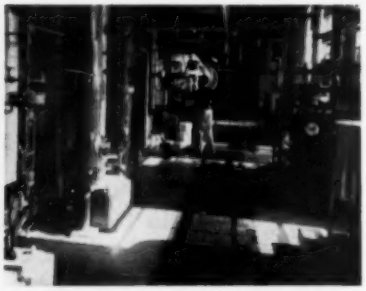
K. Hao Hsiao, a piping stress analyst and consultant, received his formal education from Stanford University, holds BA and MA degrees from that school. His first professional assignment was in the Mechanical Engineering Department of Ohio State University. Since, he has worked for Aluminum Limited and Canadair Limited in Montreal, and Stadler, Hurter & Company, consulting engineers. Prior to establishing his own practice, K. Hao Hsaio has also worked with Ralph M. Parsons Company and Ehrhart & Associates as a structural designer and piping analyst.

Du Pont FOA-2 is added to residual fuel as it's pumped into sludge-ridden tank.

$20 worth of FOA-2 saved $800 desludging job ...and with no downtime

A power plant serving two industrial laboratories burns between 1,000 and 1,500 gallons of residual fuel, daily, from a 50,000-gallon tank.

Recently, it was discovered that six inches of sludge had accumulated in the bottom of the tank. Constant temperature had to be maintained in the laboratories, so a tank-cleaning firm was called in. They gave a firm estimate of $800 for cleaning the tank mechanically. Considerable downtime would be required.



This is the powerhouse that *had* to maintain service, so that essential temperature control, in the laboratories it served, could also be maintained.

Looking for an alternative, the power superintendent decided to try using Du Pont Fuel Oil Additive No. 2 to break down the sludge. After one week of operation, during which only $20 worth of FOA-2 was used, no sludge could be detected. Moreover, there was no downtime. *The tank was in use all during the clean-up period.* Boiler room operations were completely trouble-free throughout the time the sludge was being dispersed and burned with the oil.

In addition to sludge removal, prevention of sludge is an improvement FOA-2 gives residual fuels. It is an excellent stabilizer, solubilizer, and dispersant.

Being nonmetallic, the additive burns with the fuel, leaving neither ash nor other residue. Refiners as well as their customers profit from the use of FOA-2, because it helps to stabilize all forms of distillate fuel oils, as well as residual fuel. These include blends such as catalytic-cracked stocks combined with straight-run products.

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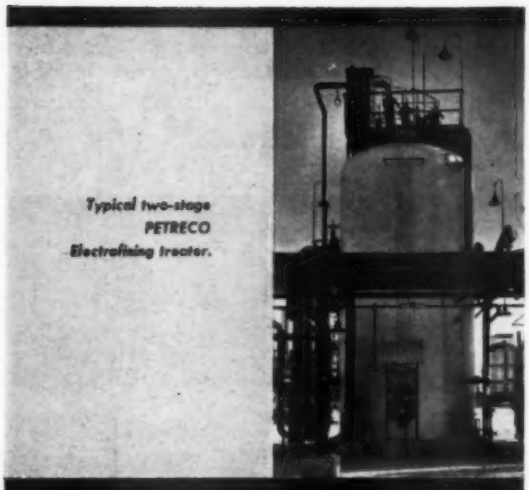
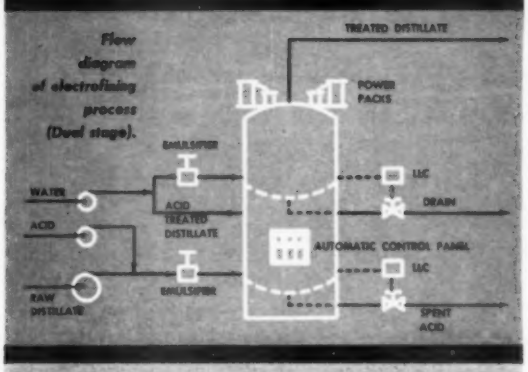


Typical two-stage PETRECO Electrofining treater.



Flow diagram of electrofining process (Dual stage).

BEFORE INSTALLING PETRECO ELECTROFINING EQUIPMENT, this Oklahoma refinery passed straight-run naphtha for reformer charge stock through its clay tower. Only half of the arsenic was removed by this treatment, and the clay lasted but a week or two. The result was a low catalyst yield.

AFTER THE PETRECO ELECTROFINER was put into operation, the same stock was treated with one lb/bbl of 90% spent alkylation acid, followed by a water wash which maintained a pH of 6.5 to 8 in the treater effluent water. The following table shows the treating results:

	BEFORE PETRECO Electrofining	AFTER PETRECO Electrofining
Arsenic (ppb)	100	4
Lead (ppb)	600	20
Sulfur (%)	.028	.015
Clay Life (days)	7 to 14	Changed only when reformer was down.
Octane of product	Normal	Normal
Catalyst Yield	Low	Up 30%
Water Carry-Over	—	Less than .001%

Petreco Electrofining can be installed *for about 1/10th the cost of hydrotreating.*

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tem must possess sufficient flexibility to minimize the detrimental effects of thermal expansion, especially for large-diameter high-alloy piping at high temperatures.

Centroidal Moments and Products of Inertia of Elbows and Bends

Applying the factors K and $\frac{K+1}{2}$ to the formulae for centroidal line inertias of elbows in Spielvogel's book, we obtain the following values for the elbow in Fig. 2:

XY plane	XZ and YZ planes
$I_{ox} = 0.149\,KR^3$	$I_{oz} = 0.149\left(\frac{K+1}{2}\right)R^3$
$I_{oy} = 0.149\,KR^3$	
$I_{oxy} = 0.137\,KR^3$	. . . . . (22)

It is evident from Equation 22 that for any circular 90-deg elbow, each of the centroidal moments of inertia about its own centroidal axes in its own plane is $0.149\,KR^3$ and the total centroidal moment of inertia about the third axis perpendicular to its own plane is $0.149(K+1)R^3$. The centroidal product of inertia in its own plane is $0.137\,KR^3$. Therefore, the summarized expressions for centroidal line inertia values for the entire system, when there are more than one elbow having the same radius of curvature R, are

$$I_{ox} = I_{oy} = I_{oz} = 0.149\,R^3[Km + (K+1)n]$$
$$= 0.149\,R^3[KN + n]$$
$$I_{oxy} = I_{oxz} = I_{oyz} = 0.137\,KR^3 \Sigma \pm \text{ signs} \quad . \quad . \quad . \quad (23)$$

The selection of sign for Equation 23 depends upon the positive directions of centroidal axes of each elbow parallel to plane of line inertia.[6] When only the positive direction of one centroidal axis cuts through the elbow circle, the term $.137KR^3$ is a positive value; otherwise, it is a negative value. Therefore, the second equation in Equation 23 is the algebraic sum of all $\pm .137KR^3$ values for elbows parallel to plane of XY, XZ, or YZ (for I_{oxy}, I_{oxz}, or I_{oyz}, respectively) i.e. $\Sigma \pm$ signs is the algebraic sum of all the positive and negative signs of products of inertia for elbows parallel to plane of XY, XZ, or YZ. Take, for instance, the elbow in XY plane, in Fig. 2. Since, in this case, the positive direction of only one centroidal axis of the elbow in XY plane cuts through the elbow circle, we use $+ .137KR^3$. When the numbers of positive and negative signs are equal, the sum of products of inertia for that plane equals zero. In this case, it is not necessary to calculate, regardless of the total number of elbows in that plane. Applying Equation 23 to the system in Fig. 3, we have

$$I_{ox} = I_{oy} = 0.149(1.5^3)\,[20.1(4) + 1] = 40.9 \text{ ft}^3$$
$$I_{oz} = 0.149(1.5^3)\,[20.1(4) + 2] = 41.4 \text{ ft}^3$$
$$I_{oxy} = 0$$
$$I_{oxz} = I_{oyz} = 0.137(20.1)\,1.5^3 = 9.3 \text{ ft}^3$$

Since the above values are negligible in comparison with the total line inertias in Table 1, they are not included in Table 1. However, when the radius of curvature R is large, or when the distances between elbows are small, it may be necessary to calculate the summarized centroidal line inertias and add them to total line inertias obtained in Table 1.

Summary of Results

To summarize the results from analyzing the system in Fig. 3, it is necessary to complete computations by obtaining the hot and cold forces for Y and Z, hot and cold moments and torques and stress ranges at the ends of piping as well as those at the point of maximum moment "d."

Assume that the piping in Fig. 3 is connected at "a" with a welding tee and at "k" to a nozzle. Then, the stress intensification factor of 1.3 for average anchor condition may be used for piping at nozzle, and that for welding tee is obtained as follows:

$$h = 4.4\frac{t}{r} = \frac{4.4(2)(0.18)}{12.75 - 0.18} = 0.126$$

$$i = \frac{0.9}{(0.126)^{2/3}} = 3.6$$

the moment and torque ranges at "a" are

$$M_a = M'_aZ = 560\sqrt{12.41^2 + 4.71^2} = 7450 \text{ ft-lb}$$
$$T_a = T'_aZ = 560(10.58) = 5930 \text{ ft-lb}$$

Hence, the stress range at "a" is obtained from Equation 19 as below:

$$s_b = \frac{3.6(7450)\,12}{22} = 14{,}630 \text{ psi} \quad s_t = \frac{5930(12)}{2(22)} = 1617 \text{ psi}$$
$$S_e = \sqrt{14{,}630^2 + 4(1617^2)} = 15{,}000 \text{ psi}$$

The values of M_k and T_k having been obtained in Table 2, the stress range at "k" can be readily obtained as follows:

$$s_b = \frac{1.3(8400)\,12}{22} = 5960 \text{ psi}$$

$$s_t = \frac{207(12)}{2(22)} = 56.5 \text{ psi}$$

$$s_e = \sqrt{5960^2 + 4(56.5)^2} = 5960 \text{ psi}$$

Comparison of the above two s_e values with s_e at "d" indicates that the latter is controlling. The required hot and cold reactions can be obtained by tabulation as below:

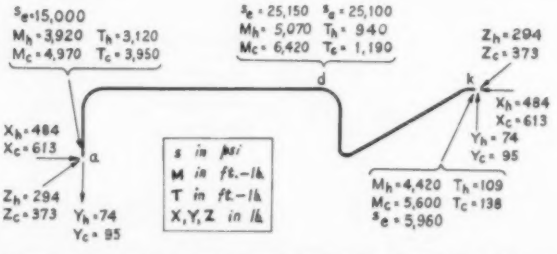
From Equation 18, for c = 0.5

$$\left(1 - \frac{2}{3}c\right)\frac{E_h}{E_c} = \frac{2}{3}\left(\frac{21.6}{27.4}\right) = 0.526$$

$$\left(1 - \frac{s_h}{s_e}\right)\frac{E_c}{E_h} = 1 - \frac{6600}{25{,}150}\left(\frac{27.4}{21.6}\right) = 0.667$$

Reaction	Conversion factor	At "d" M_d	At "d" T_d	At "k" M_k	At "k" T_k	At "a" M_a	At "a" T_a	At "a" and "k" Y	At "a" and "k" Z
		9640	1788	8400	207	7450	5930	142	560
Hot	0.526	5070	940	4420	109	3920	3120	74	294
Cold	0.667	6420	1190	5600	138	4970	3950	95	373

The above numerical results together with X_h, X_c, s_e and s_n at "d" already obtained are shown diagrammatically in the chart below.

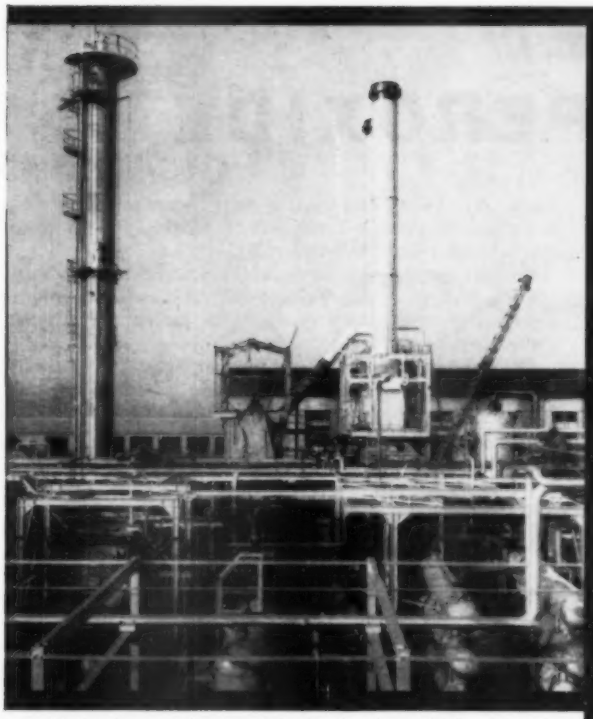


Editor's note: See Part 1 of this series, in the May issue of *The Refining Engineer*, for nomenclature. Part 3 will appear in the July issue.

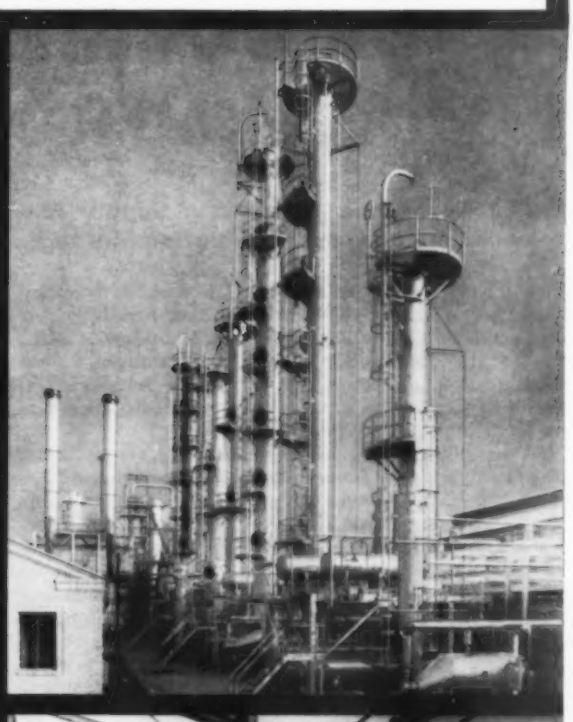
[6]Same as the positive directions of axes of piping system.

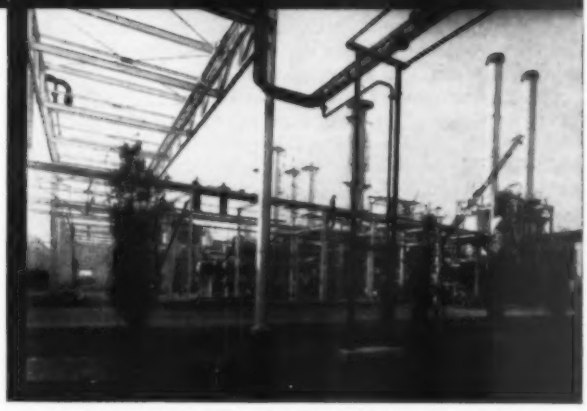
In Germany...

ANOTHER JOB WELL DONE BY PROCON



Heat exchanger in foreground, fractionation tower at left and heater stacks on right during construction.





Top—Fractionation section of the finished Platforming and Unifining units.

Bottom—Nearing completion, heat exchangers, left, in series with the fractionation section and heaters on the right.

Procon construction helps rebuild Deutsche Erdöl A.G. refinery at Heide, Germany

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PHENOL and ACETONE via CUMENE HYDROPEROXIDE

Peter W. Sherwood,
Chemical Engineer
White Plains, New York

Part 1: Economic Factors in Supply and Demand, and Production Methods.

THE CUMENE HYDROPEROXIDE route to phenol is barely five years old. First commercial operation of the process occurred in the spring of 1953 at the Montreal, Canada plant of B. A. Shawinigan. Today, nine manufacturers the world over are operating or constructing commercial cumene hydroperoxide process facilities with a combined phenol capacity estimated at 170 million lb per year.

In the United States, three producers are involved: Allied Chemical and Dye Corporation (Barrett Division) with rated capacity of 30 million lb per year; Standard Oil Company of California, with estimated phenol production potential at 35 million lb, and Hercules Powder Company, capable of producing 26 million lb per year phenol via cumene hydroperoxide. In addition, Allied has announced plans which would essentially double its present phenol capacity. Total 1956 production of phenol by the cumene hydroperoxide process was 93.8 million lb in the U. S.

The following use the cumene hydroperoxide route in foreign countries: B. A. Shawinigan in Canada, Progil-Electrochimie and Rhone-Poulenc in France, Phenolchemie in Germany, Societe Chimique des Derives du Petrole in Belgium, and Mitsui Petrochemical in Japan.

This rapid expansion points up continuing favorable outlook for phenol as a growth chemical as well as attractive long-range economics of the cumene hydroperoxide route which uses benzene and propylene as raw materials and yields phenol plus acetone as co-products. It will be the purpose of this paper to consider some of the economic and technical factors which are involved in this method of phenol production.

Overall Market Trends

The CHP process yields approximately 61 lb acetone per 100 lb phenol. Economics of the process are therefore strongly influenced by markets, competitive factors, and price structure of both main products.

In addition, minor quantities of methyl styrene, alpha-methyl styrene, and acetophenone are obtained. These by-products are, however, of secondary importance; only one U. S. manufacturer is known to practice their recovery from the CHP process.

Fig. 1 shows growth curves for phenol production and sales. Increase in difference between these two curves is quite marked and is due to greater captive use of phenol. There are several reasons for this; manufacturers of phenol derivatives, especially those of phenolic resins, have chosen vertical integration — securing their own raw materials position against wide price fluctuations. Secondly, phenol manufacturers have entered in increasing measure production of phenol derivatives. This trend is due to desire to secure markets for their primary commodity, a general drive toward diversification into profitable ventures.

Finally, phenol tends to discolor and deteriorate in storage. Its derivatives can be held in inventory for a longer time thus permitting the producer to smooth out demand fluctuations.[1]

Distribution patterns. Overall manufacture of phenolic resins takes the commanding lead among markets for phenol. Since they were first introduced commercially in 1909, this group of thermosetting resins has maintained a prime position. Production of the resin in 1956 was some 510 million lb; 1957 total is expected to be about the same, possibly less.

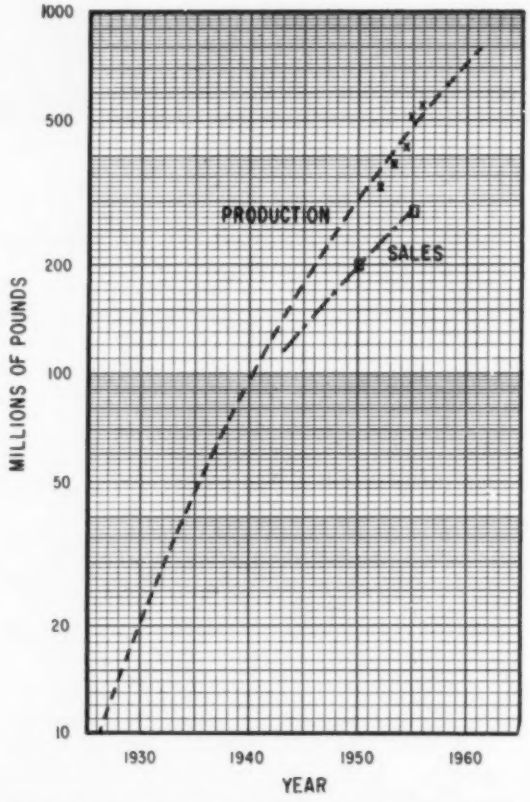

FIG. 1. Trends in United States production and sales of phenol.

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Based on U. S. Tariff Commission data, this 1956 distribution pattern of phenolics is estimated:

End Use	Production (Million lb)
Molding materials*	215
Bonding and adhesive for laminating	63
Coated and bonded abrasives	15
Friction materials, brake linings, etc.	10
Thermal insulation	56
Plywood	44
Protective coating resins	29
Resins for all other uses	77
	509

*Includes fillers, plasticizers and extenders.

The dominant position of molding materials is quite evident. Providing further insight into end uses of phenol, distribution pattern of phenolic resins is estimated as follows:[7]

Phenolic Molding Power End Use Volume (1956)

	Million lb
Electrical control parts (panel boards, switch gear, etc.)	35
Housings, including television	9
Wiring devices	23
Closures	17
Utensil and appliance handles	12
Telephones	5
Washing machines	10
Automotive	7
Vacuum tubes, radio and TV parts	8
Miscellaneous	79
	205

Phenolics have a fairly well defined area of application. Their growth is governed, above all, by growth of the entire economy. Probably the most important single recent development affecting phenolic resins is acceptance of shell molding technique in foundries. This use made its commercial debut in 1950. In 1955 it consumed some 15 million lb, and outlook is for use of 45 million lb in shell molding by 1960.

Average consumption of phenol is about 0.65 lb per pound phenolic resin produced. In 1956, production of phenolic resins therefore accounted for 330 million lb of phenol or some 60 percent of total production.

In second position among phenol consumers is synthesis of miscellaneous chemicals. Here, the production of 2, 4 D- and related weed killers is in the lead. This group of chemicals has shown a strong growth trend. Phenol utilization in its manufacture rose from negligible amounts in 1944 to 28 million lb in 1956.

Strongly on the uptrend is manufacture of bisphenol-A, used in production of epoxy resins, as well as of polycarbonates, a new class of plastics. Bisphenol-A output is estimated to be about 10 million lb per year. Outlook for 1962 is about three times this amount. One hundred pounds of bisphenol-A consume some 97 lb of phenol: This chemical thus accounts for about 9.7 million lb phenol at present.

Rounding out the list of phenol derivatives are salicylic acid (aspirin), penta chlorophenol, picric acid, and a miscellany of lesser chemicals. Adipic acid (for nylon) employs phenol as starting material in some foreign plants, but in the United States this chemical is produced from cyclohexane.

An estimated 8 to 10 percent of phenol production enters trade as such. Principal application of this type is as solvent in extraction processes, primarily, in petroleum refining. It is used also as disinfectant, as an addition agent in copper plating, and in numerous minor applications, including leather and textile dyeing.

Long range outlook for phenol. Overall outlook continues to be good. Extrapolation of the (Gompertz) trend curve for phenol production forecasts a rise from 549.2 million lb in 1956 to 790 million lb in 1961 (see Fig. 1).

More detailed consideration of market components for phenol suggests, however, that this growth rate may be somewhat optimistic. Phenolic resins continue to be the largest consumer of phenol; we may not expect any surprising new developments in uses — on the market for some 50 years — and now bearing competition from newer low-cost plastics.

Looking further into the future, there is wide divergence of opinion. Lum[1] cites a prediction of 1256 million lb for phenol production in 1975. This compares with 2806 million lb for phenol production in 1975 by the President's Materials Policy Commission in 1951. The range is too wide to be meaningful.

Outlook for acetone. Attractiveness of the cumene hydroperoxide route to phenol in relation to competitive methods of manufacture depends in large measure on the producer's ability to dispose of co-product acetone at an attractive price. An economic view of the CHP process must therefore also give careful consideration to market developments and outlook for acetone.

Unlike phenol, acetone production has been well below capacity for nearly a decade now. 1957 output, estimated at approximately 600 million lb, is only about 75 to 80 percent of installed capacity.

Nor is there any likelihood that this situation will be relieved in the near future. Markets for acetone will not catch up with today's installed capacity (estimated at 800 million lb per year) until 1960. At the same time, acetone is being obtained in increasing measure as by-product or co-product of various operations (see below), and there continues to be expansion in propylene hydration, primary source of acetone. All of these factors tend to retain the present buyer's market for acetone.

A look at principal outlets for acetone does not show any major area where future rapid expansion may bring real relief. Both acetone and its chief derivatives find principal uses in the highly competitive field of solvents applications, directed most particularly into industries that show only moderate growth rate.

Estimated end-use acetone in 1957,[3] compared to the situation prevailing in 1951[4] is:

	Million lb 1957	1951
Derivative solvents:		
methyl isobutyl ketone, carbinol, and others (mesityl oxide, diacetone, hexylene glycol, isophorone, etc.)	195	154
	60	53
Methyl methacrylate (via acetone cyanhydrin)	75	28
Miscellaneous chemicals (bisphenol-A, chloroform, etc.)	80	40
Paint, varnish and lacquer solvent	65	40
Cellulose acetate solvent	60	155
Acetylene solvent	30	25
Misc. solvent, etc.	50	21
Total domestic consumption	615	516

Percentage-wise, only important expansion during 1951 to 1957 took place in non-solvent uses, notably as raw material for methyl methacrylate (a monomer for plastics production) and bisphenol-A (growth of bisphenol-A, a product of both phenol and acetone, was mentioned in the discussion of markets for phenol).

In terms of total volume, these outlets carry little weight when compared to the less rapidly expanding markets for acetone and acetone-derived solvents.

Most important of these are methyl isobutyl ketone and carbinol. Solvent uses for the ketone cover a wide range of applications, includes such materials as polyvinyl chloride-acetate copolymers (of principal interest in surface coatings), polyacrylic esters, nitrocellulose, cellulose acetate-butyrate, DDT, and pyrethrum. MIBK is used also for extraction of penicillin and other antibiotics, as dewaxing agent for lubricating oils, and as dispersant for organosol type resins.[5]

Not quite so wide-spread are applications of methyl isobutyl carbinol, an acetone derivative obtained by hydrogenation of methyl isobutyl ketone. This alcohol finds its most important employment as solvent. It also serves as frother in

DU PONT *Petroleum Chemicals* NEWS

Number 88 in a Series of Bulletins for the Petroleum Industry

JUNE 1958

$20 worth of FOA-2 saves $800 mechanical de-sludging job...with no downtime

When sludge fouls oil storage tanks, filters, strainers, lines and nozzles, there are two remedies. One is to remove the sludge mechanically and manually. This means downtime and considerable other expense.

The alternate way is to clean the system chemically. This is far cheaper, and there's *no downtime* involved.

The economy and effectiveness of this method are exemplified by a recent case history:

DuPont FOA-2 is added to residual fuel as it's pumped into sludge-laden tank.

A power plant serving two industrial laboratories burns between 1,000 and 1,500 gallons of residual fuel daily, drawn from a 50,000-gallon storage tank.

6 inches of sludge

Recently, it was discovered that six inches of sludge had accumulated in the bottom of the tank.

A tank cleaning firm was called in. A firm estimate of $800 was obtained for cleaning the tank mechanically. Considerable downtime would be required.

But since a constant temperature

Chemical industry's demand for oil grows

"Dacron"* an example of volume consumption

Uniforms of DuPont "Dacron" polyester fiber have been widely adopted for service station attendants. The garments are remarkably acid-resistant, can be washed or dry-cleaned, and are unusually durable. What's more they *hold* creases, *resist* wrinkling, *stand up* under the rigorous routine of the busy service station.

Huge quantities of other synthetic fibers, such as nylon, also are made from oil. In fact, petroleum products have in recent years become such an important source of raw materials that many chemical companies, DuPont included, have located plants in refining areas so as to be near an ample source of petroleum-derived raw materials.

**"Dacron" is DuPont's registered trademark for its polyester fiber.*

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OVER

DU PONT *Petroleum Chemicals* NEWS

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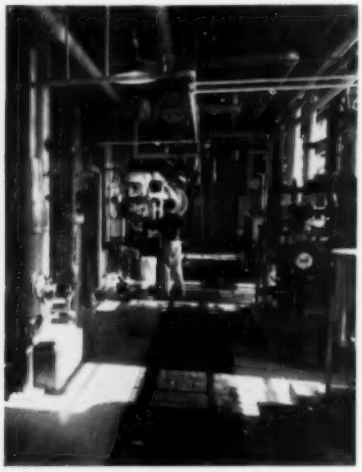
had to be maintained in the laboratories, the power plant could not afford the downtime. Looking for an alternative, the power superintendent decided to try dispersing the sludge with DuPont Fuel Oil Additive No. 2 (FOA-2).

Constant operation

$20 worth of FOA-2 was added with the next load of fuel oil delivered. A week later, no sludge could be detected. And the tank was in continuous use during the clean-up period.



THIS IS THE POWERHOUSE that *had* to maintain service, so that essential temperature control, in the laboratories it served, could also be maintained.

At the end of the week, throughout which time boiler room operations were completely trouble free, it was found that the entire sludge accumulation had been dispersed and burned with the fuel.

Sludge prevention

In addition to sludge removal, *prevention* of sludge formation is another important function of DuPont FOA-2. It is an excellent stabilizer and solubilizer, as well as a dispersant, for all types of fuel oils.

Being nonmetallic, this additive burns completely with the fuel, leaving neither ash nor other residue.

For more detailed information about DuPont FOA-2 and its use as a tank-cleaning agent, get in touch with one of our sales offices listed at right. They have a new FOA-2 booklet, and Technical Memorandum 317 which contains a number of case histories.

How one refinery solves residual sludge problems with Du Pont FOA-2

In the heating plant of a midwest refinery, residual fuel with 40% BS&W, most of which was "coke," was being used. Frequent cleaning of the storage tank was required to prevent the nozzles from clogging and the burners from flaming out.

FOA-2 tried

Following one of the clean-outs, DuPont Fuel Oil Additive No. 2 (FOA-2) was added to the incoming oil stream to disperse sludge residue and stabilize the fresh oil supply.

BEFORE FOA-2—This picture shows a typical instance of nozzle fouling caused by sludge in residual fuel.

AFTER ADDING FOA-2—Nozzles stay clean, burner operation is improved, and tank contents remain free of sediment.

The results were gratifying. After the additive was used for three weeks, there was no detectable sludge in the storage tank. Normally in this length of time the sludge level would have built up in the tank sufficiently high to cause pumping difficulties.

Flame pattern improved

When the burners were examined, the flame pattern was found to be better. Also, fewer ash deposits were found in the furnace and the over-all burner operation was improved.

This money-saving improvement and the elimination of frequent, costly cleanings resulted from the highly efficient dispersing, stabilizing and solubilizing qualities of DuPont FOA-2. It can equally well improve the distillate fuel oils you sell or use yourself.

A recently-published booklet on FOA-2 contains all the basic information on the many varied applications of FOA-2. There is also a bulletin of case histories that you will find of interest—our Technical Memorandum No. 317. You can obtain this literature by writing or contacting the nearest DuPont Petroleum Chemicals Division sales office.

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ore flotation, and as an intermediate in manufacture of methyl isobutyl acetate (another solvent) and some minor derivatives.

Of potential interest is use of acetone as raw material in acetic anhydride synthesis. This process is employed commercially in England but falls short of competitive requirements in the United States.

Competitive Production Methods

The cumene hydroperoxide process now accounts for only about 17 percent of phenol output and 8 to 9 percent of acetone production in the United States. Economics of competitive methods of manufacture for both products are close and construction activities of the last four years have not been confined to any single process.

Some 6.4 percent of 1956 phenol production was obtained by direct recovery from coal tar. Amount available from this source is, of course, intimately related to coke production and is thus a function of steel production, ultimately.

Expansion rate of the iron and steel industries falls far short of even today's decelerated growth requirements for phenol. A forecast anticipates a 145 percent increase in natural phenol production between 1950 and 1975.[1] This is about equal to the expected 150 percent expansion in gross national product during that period. It falls far short of the 300 to 500 percent growth in requirements that has been variously predicted.

Thus, bulk of phenol production is and will be obtained synthetically. Volume-wise, the leading process calls for monochlorination of benzene followed by high temperature hydrolysis of chlorobenzene in alkaline solution. This approach is used by only one U. S. firm — Dow — the largest single producer of phenol.

Chlorobenzene serves also as intermediate in the Raschig process of phenol synthesis, used by Durez Plastics Company at Tonawanda, New York. Here, chlorobenzene is obtained by catalytic reaction of HCl with benzene in presence of air. In a subsequent stage, chlorobenzene is hydrolized to yield phenol plus MCl. The latter can be recycled to the chlorination stage. Theoretically, this process requires only benzene as raw material. Actually, there are HCl make-up requirements as well, amounting to some 5 to 6 lb per 100 lb phenol.

Sulfonation processes are used by four American producers of phenol. This approach is particularly suitable for installations of relatively small size. Benezene is reacted with sulfuric acid to yield benzene sulfonic acid which is subsequently neutralized and subjected to alkaline fusion to yield the sodium salt of phenol.

A potential source of natural phenol is high-pressure coal hydrogenation and in shale oil operations. Neither is at all significant today. The only coal hydrogenation plant in the United States, operated by Carbide and Carbon Chemicals Company, is capable of yielding 3 million lb per year of tar acids; most of these are higher alkylated derivatives of phenol.

A small shale oil refining unit is to be operated by Union Oil Company. This operation will, however, be directed entirely toward production of hydrocarbon fuels without recovery of contained phenolic and other chemical values.

Even so, coal hydrogenation and shale oil production deserve brief consideration because of their potential source value. As generally known, both of these processes may serve for the production of liquid hydrocarbon fuels. It is estimated that an 800,000 bbl per day liquid fuel production by coal hydrogenation can be made to yield 1.3 billion lb phenol (plus 1.2 billion lb higher tar acids) as by-product. A like amount of liquid fuel produced from shale oil would yield between 4 and 12 million lb per year phenol — depending on the method of oil refining — plus about four times as much cresols.

In light of these potential recoveries, various estimates widely publicized on which synthetic fuels processes — and particularly coal hydrogenation — would flood the phenol market.

There is nothing in today's picture which would support such a view in the foreseeable future. Current outlook is that petroleum supplies are adequate to stave off costly synthetic fuels processes for at least 10 or 20 years. Even if production of hydrocarbons from coal should ever become a reality, it is highly questionable that high-pressure hydrogenation would be the approach in light of technology prevailing at such future date.

Alternative Acetone Processes

Like phenol, acetone produced via cumene hydroperoxide must meet competition of several other sources.

Least important but oldest source of acetone is a fermentation process. Installed capacity for this method of acetone production is estimated at 50 million lb per year. Derived "natural" acetone has been hit hardest by growing availability of by-product acetone. In 1953, fermentation capacity was utilized almost fully. Outlook now is for operation at only about 30 percent of fermentation capacity or less, accounting for less than three percent of total United States acetone output.

The bulk (approximately 80 percent) of acetone production is obtained by hydration of propylene to isopropanol, which is subsequently dehydrogenated to acetone. This is one of the oldest petrochemical operations. It continues to be economically attractive, some 150 million lb per year will have been added to U. S. isopropyl-alcohol-acetone capacity during the years 1956-1958.

Third-largest source of acetone (after isopropyl alcohol and cumene hydroperoxide) is direct oxidation of propane-butane mixtures. The process, practiced by Celanese Corporation and Warren Petroleum Company, yields a number of oxygenated products, among them acetone. According to the U. S. Tariff Commission, some 35 million lb per year acetone is obtained from this source.

An interesting newcomer to the field is Shell Chemical Company's new glycerine process at Norco, Louisiana. Acetone is obtained as by-product of two intermediate reactions: (1) Partial oxidation of isopropanol to hydrogen peroxide and (2) reduction of acrolein to allyl alcohol, by hydrogen exchange with IPA. It will be noted that, in this case, isopropyl alcohol continues to be the intermediate but that the conversion of IPA to acetone is incidental to other chemical objectives.

Finally, availability of acetone as a by-product of gas synthesis (i.e., a modified Fischer-Tropsch process for the production of hydrocarbon oils from water gas) is a possible factor. A 12,000 bbl per day plant of this type can yield an estimated 22 million lb acetone per year; the process thus holds potential to flood the acetone market as well as for other oxygenated aliphatics.

Gas synthesis is not an attractive process at present or under foreseeable economic conditions in United States, especially in the light of the evident adequacy of petroleum supply and discoveries. The only American plant of this type, located at Brownsville, Texas, has had a checkered career since 1948 and was finally shut down by its present owner (Standard Oil Company of Indiana) in September 1957.

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4. Nieuwenhuis, H. K. *Chemical Week*, May 2, 1953, p. 30.
5. Sherwood, P. W. *Pet. Ref.* December 1954, p. 144.
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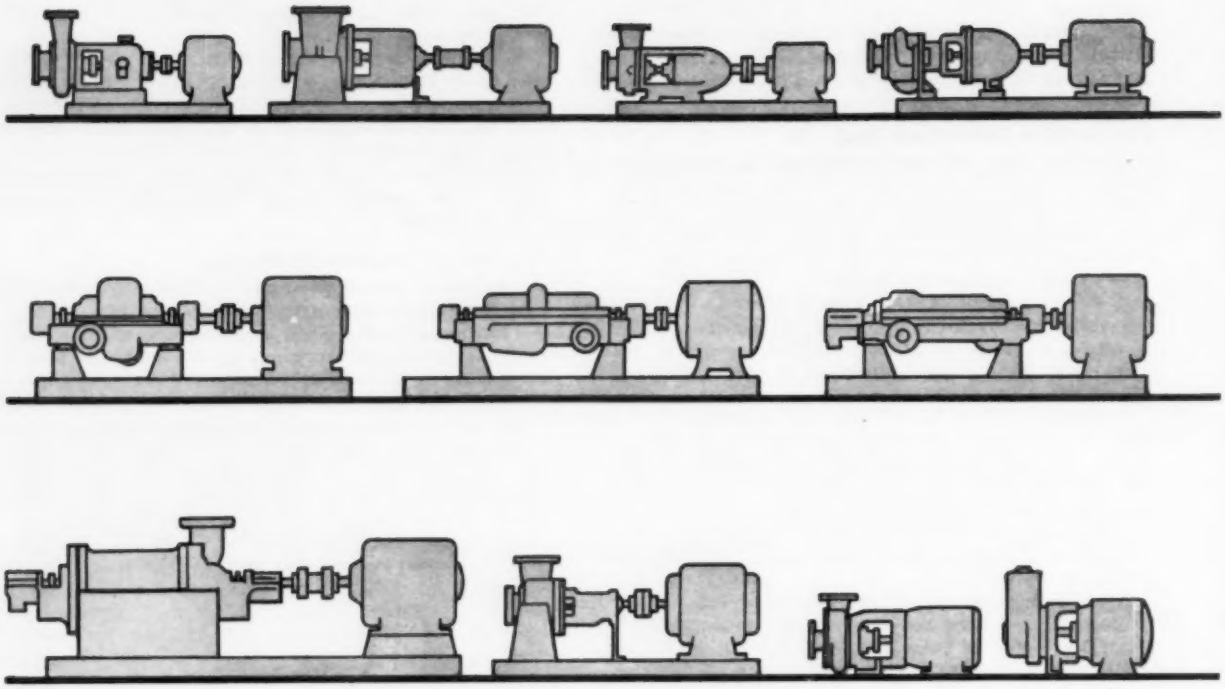
7. *Modern Plastics*, January 1957.

Peter W. Sherwood will describe the *Phenol and Acetone via Cumene Hydroperoxide* process in detail next month, in the second of this two-part series.



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2 *What if I need a "special" pump?*

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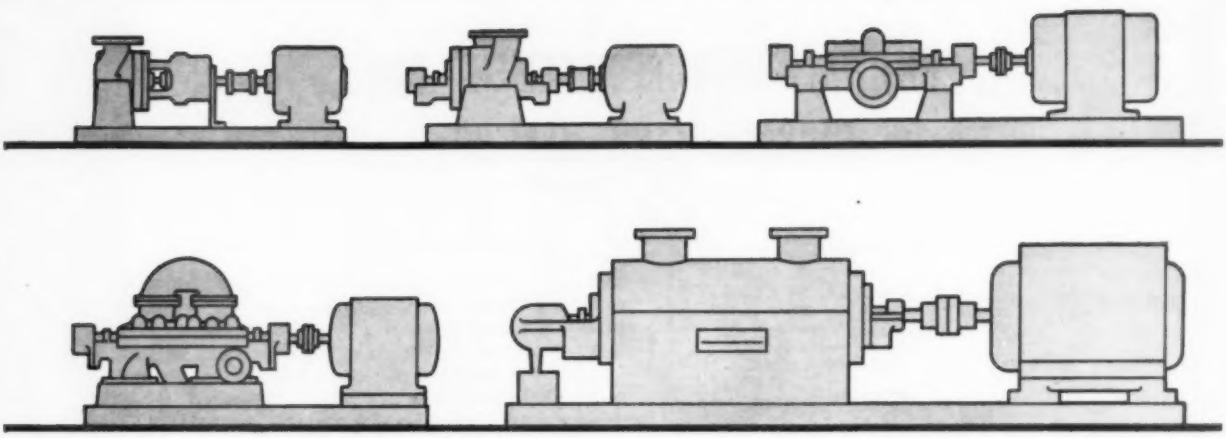

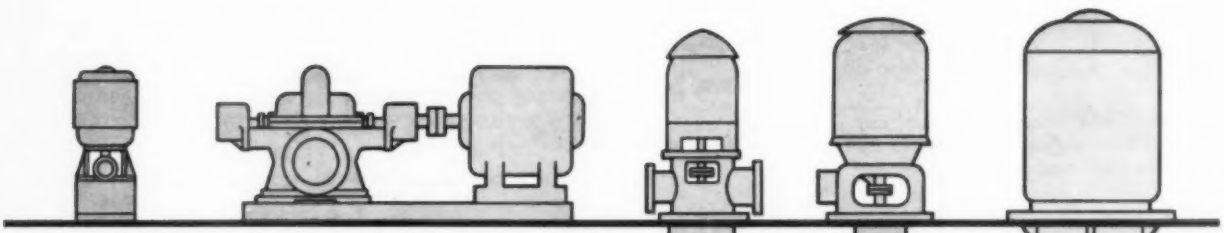

your process?

3 How about operating cost?

There aren't any secrets about pump efficiency . . . all you have to do is look at the performance curves. But *long-term* efficiency is something else! And Ingersoll-Rand pumps have built their reputation on long-term efficiency and ease of maintenance. For example, examine the running clearances on any I-R pump . . . they're realistic and can be maintained over years of constant full-capacity service without frequent replacement of wearing parts.

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Without obligation on your part, I-R pump specialists will evaluate your process requirements and make constructive suggestions on pump selection. Elevation prints and performance curves will be provided to help you with mechanical and hydraulic design problems. Manufacturing that is coordinated with your requirements means that you get delivery when you want it. And Field Erection Service is always available, to assure proper installation . . . *on time.*

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$$KWH = \frac{Q}{3415} = \frac{V \times .134 \times p \times 62.5 \times Cp \times \triangle T}{3415}$$

where: p = specific gravity of the material,

V = volume of material in gallons,

Cp = mean specific heat of the material in Btu/lb/deg F,

$\triangle T$ = temperature differential in F,

Q = heat required in Btu.

Having determined the electrical energy in KWH, and knowing the time available for heat-up the appropriate size heater can be obtained.

Example

Required: The rating of a heater to raise 1000 gal of a liquid whose specific gravity is 1.0 and specific heat is .5 from 50 F to 150 F in 3 hours.

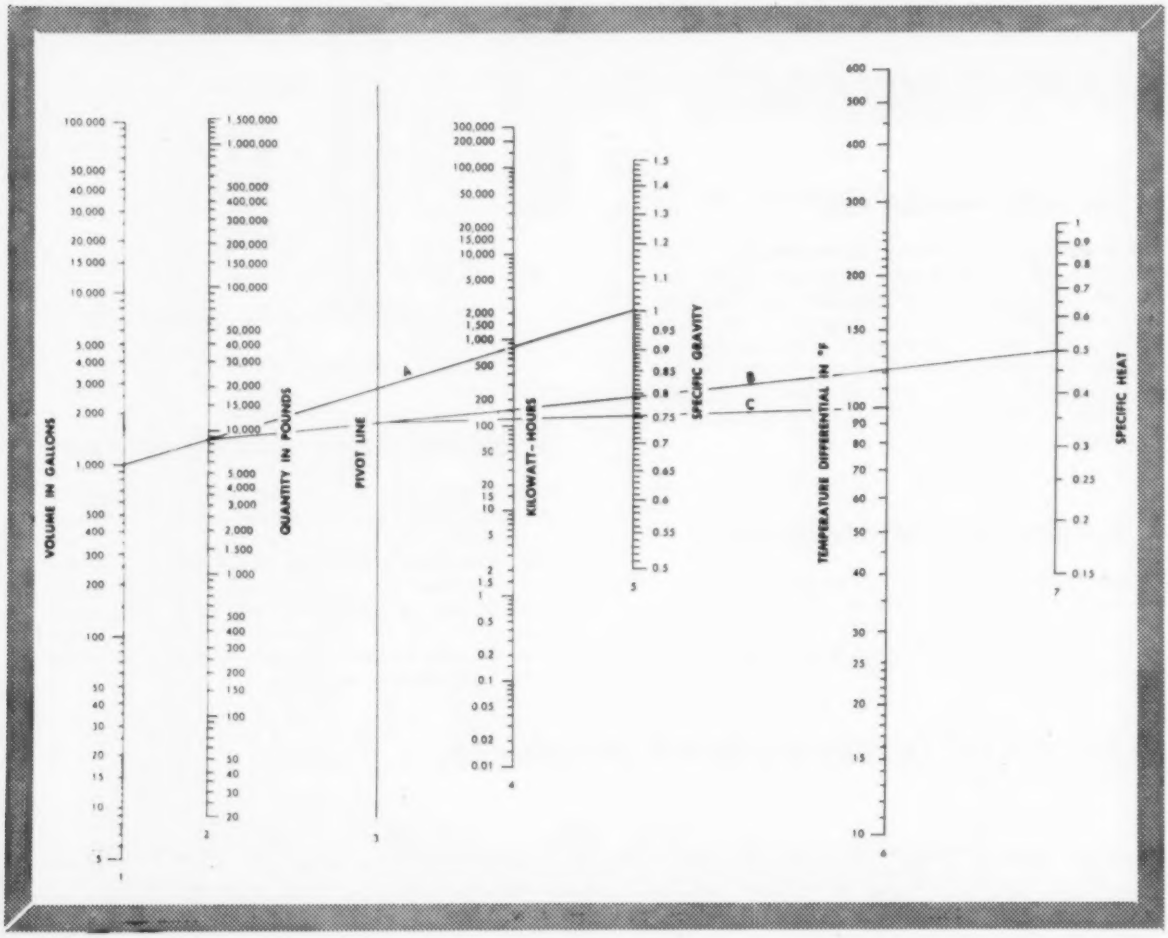
A. Determine the weight of the liquid (not necessary if weight of material is known) by joining 1000 gal on scale (1) with 1.0 on scale (5) by the straight line (A) reading the weight of 8400 lb on scale (2).

B. Connect the above reading on scale (2) with 0.5 on scale (7) by the straight line (B).

C. Connect the intersection of line (B) on scale (3) with 100 F on scale (6) by the straight line (C) and read 120 KWH on scale (4).

Since a total energy input of 120 KWH is required, a heater rated at 40 KW will supply 120 KWH in 3 hours.

Courtesy Hynes Electric Heating Division, Turbine Equipment Company



Glycol - Amine Gas Treating

Licensed by: The Fluor Corporation, Ltd.

DESCRIPTION: The flow sheet for this process is the same as for conventional aqueous amine treating. The difference is in composition of the treating solution, which contains a large concentration of glycol. While other glycols are equally applicable, diethylene glycol is commonly employed.

Designed originally for simultaneous sweetening and dehydration of natural gases, this process has been used elsewhere because of the high product purity that can be attained. Purities of 0.25 gr of H_2S/100SCF are normally guaranteed; higher purities can be obtained.

Advantages are claimed in reduction of corrosion, permitting use of aluminum tubes in exchangers and the reboiler where carbon steel and alloys have failed. Also, suppression of foaming and reduction in steam consumption is noted.

FEEDSTOCK: Any gas containing H_2S and/or CO_2.

SERVICE FACTOR: 95 - 98 percent.

UTILITIES: Requirements shown are referred to circulation rate. One gallon of solution will absorb about 3 SCF of acid gas, depending on feed composition and purity requirements.

	Per gpm of Solution
Steam	50-70 lb/hr
Power	0.5-1.0 kw
Cooling Water	4-6 gpm

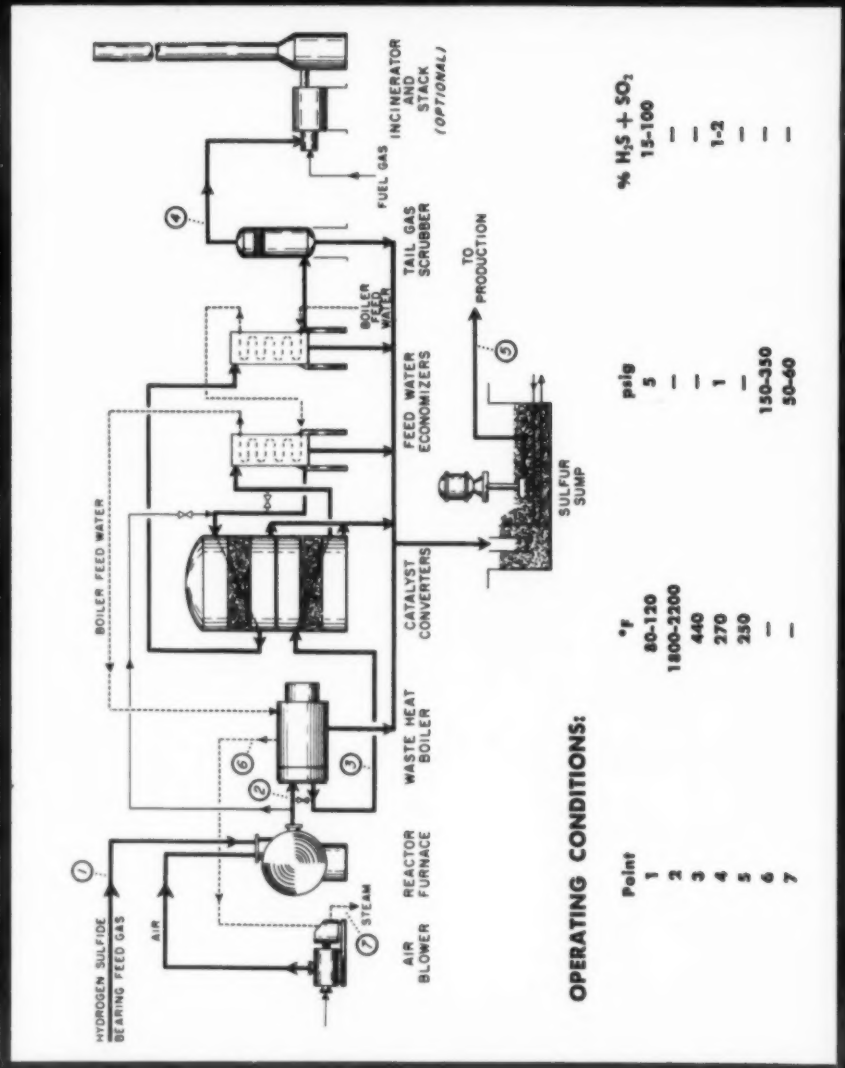
OPERATING PERSONNEL: 2 men per shift.

INVESTMENT: $1000 - $2000 per gpm solution.

MAINTENANCE: 3-4 percent of investment annually.

Sulfur from H_2S

Licensed by: The Fluor Corporation, Ltd.



OPERATING CONDITIONS:

Point	°F	psig	% $H_2S + SO_2$
1	80-120	5	15-100
2	1800-2200	—	—
3	440	—	1-2
4	270	—	—
5	250	—	—
6	—	150-350	—
7	—	50-60	—

Sulfur from H_2S

Licensed by: The Fluor Corporation, Ltd.

DESCRIPTION: Feed gas, along with a controlled quantity of air, enters the reactor furnace for SO_2 formation. One third of the H_2S is oxidized to SO_2 here. The gas then flows through a waste heat boiler for heat removal, passes to a catalyst bed for further reaction and then to an economizer where free sulfur is condensed.

Gas from this economizer flows to a second catalyst bed for further reaction, then to a second economizer for sulfur condensation. Entrained sulfur is removed in a tail gas scrubber. Exit gas may either be discharged directly to the atmosphere or incinerated, depending on pollution problems.

Boiler feed water flows countercurrent to the gas, first entering the last economizer, then the first, then the waste heat boiler. This system serves the dual purposes of heat recovery and temperature control.

No burners are used in this process, except for initial heating during start-up. The plant can be restarted after 2-3 day's downtime simply by turning on the feed gas.

FEEDSTOCK: This process can handle any H_2S-containing gas; it has operated on gasses as lean as 15% H_2S. Hydrocarbon content of feed gas is important — 2% is typical, but more can be handled by increasing plant size. It should be noted that aromatics are undersirable.

PRODUCTS: Sulfur — 99.8% + pure.
Steam (50-60 psig) — 200 lb/hr per daily ton sulfur.

SERVICE FACTOR: 90-95 percent.

OPERATING PERSONNEL: 1½ men per shift.

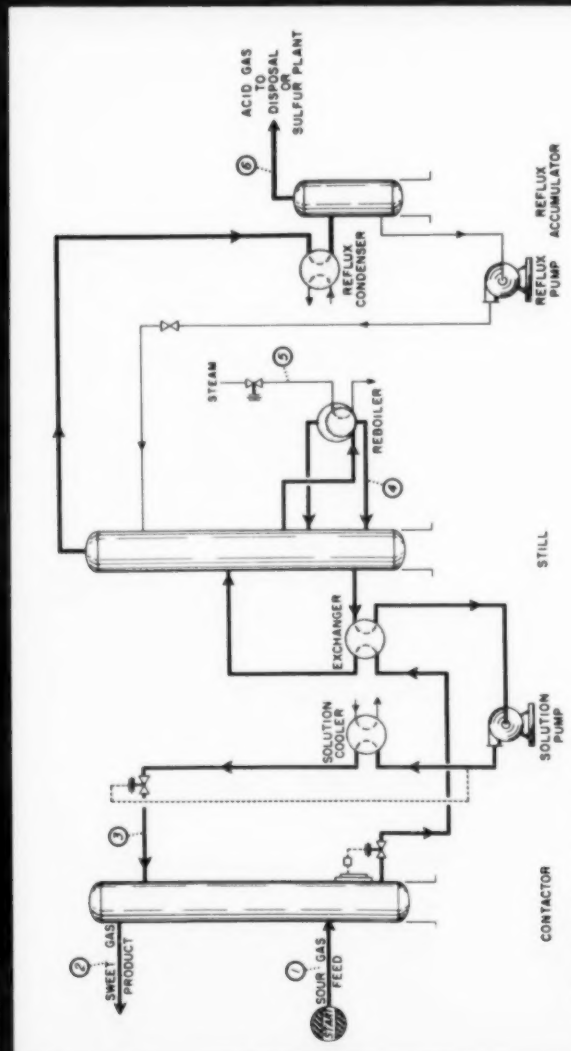
CATALYST: Boiler feed water — 0.4 gpm per daily ton sulfur. Other utilities — neglible.

INVESTMENT: $5000-$8000 per daily ton sulfur production.

MAINTENANCE: 4-5 percent of investment annually.

Glycol - Amine Gas Treating

Licensed by: The Fluor Corporation, Ltd.



OPERATING CONDITIONS:

Point	°F	psig	$\%CO_2 + H_2S$
1	80-120	50-1200	0.1 - 50
2	80-120	50-1200	< 0.25 gr H_2S/100SCF
3	70-110	50-1100	
4	300	10	
5	—	100	
6	100	5	

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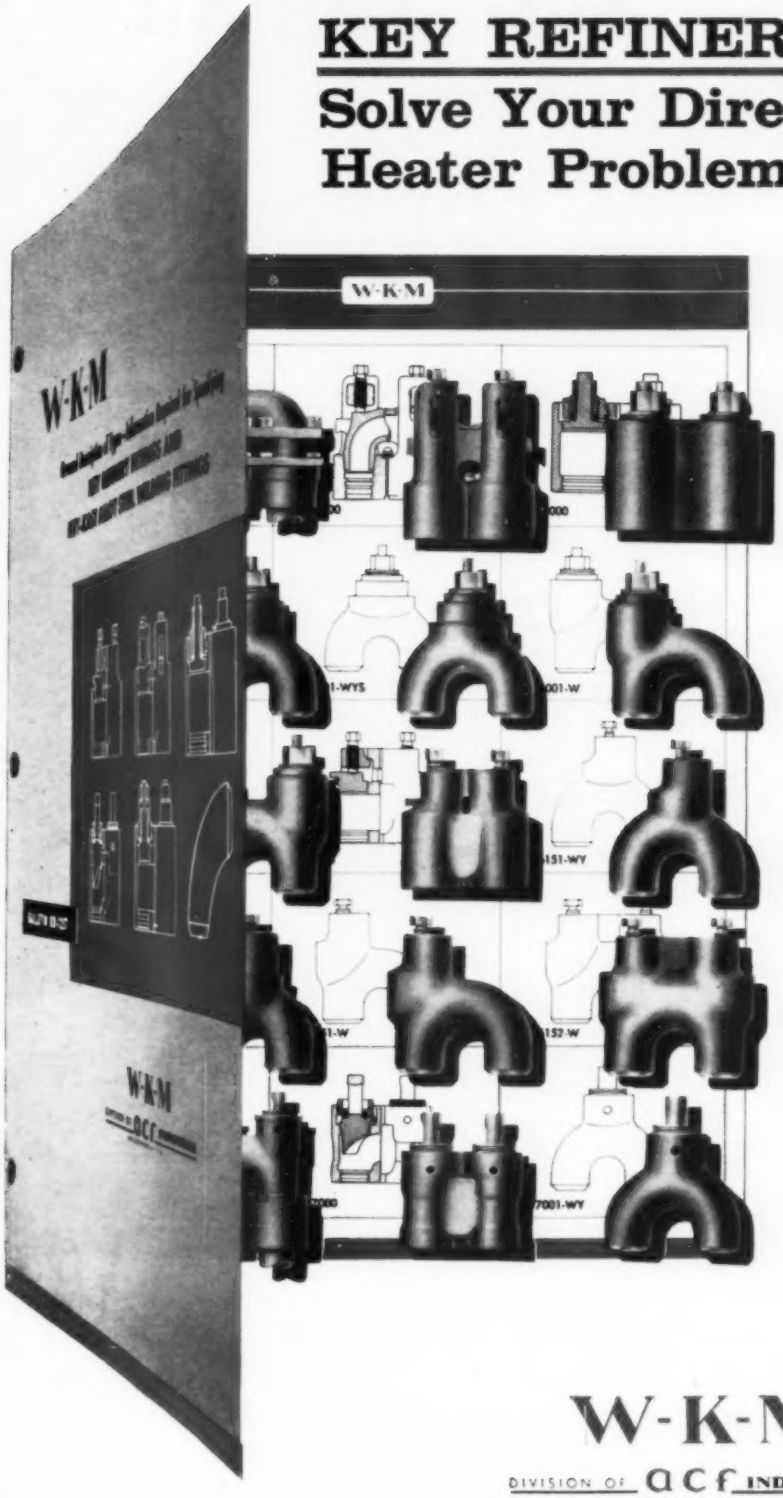

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Electrical resistance method speeds . . .

MONITORING REFINERY CORROSION

A. J. Freedman, *Senior Project Supervisor*
A. Dravnieks, *Corrosion Section*
E. S. Troscinski, *Research Engineer*
Standard Oil Company of Indiana, Whiting, Indiana

UNTIL RECENTLY, only three general methods were available for corrosion investigations in refinery process equipment. These include: Unit inspections, analyses of effluent streams for metal content, and corrosion coupons. In modern complex refineries, the limitations and disadvantages of these procedures are becoming increasingly apparent, and better methods are needed.

Requirements for a good corrosion monitor. First, the method must be able to detect corrosion in operating equipment, so that protective measures and process variables can be evaluated under actual operating conditions.

Second, the method must be rapid, so that solutions to urgent problems can be tested without delay, and so that lengthy, expensive experimental programs can be avoided.

Third, the method must be accurate and reproducible, to insure that data obtained with this method will correspond to actual corrosion rates at the point of measurement.

Fourth, the method must be sensitive, so that low corrosion rates can be measured in reasonable times, and so that small changes can be detected.

And, perhaps most important, the measurements must not interfere in any way with normal refinery operations.

The conductometric method. A corrosion-monitoring procedure which fulfills all of these stringent requirements is the conductometric, or electrical resistance method. It has been used extensively for industrial laboratory corrosion testing and in plant operations. A large number of electrical resistance corrosion probes have been installed in refineries for many different applications.

The electrical resistance technique of measuring corrosion has been discussed in papers from this laboratory published during 1954 and 1957.[1, 2] Briefly, it consists of measuring change in electrical resistance of a metal specimen placed in a corrosive medium. Since the resistance of an electrical conductor is inversely proportional to its cross-section, change in resistance of the specimen with time can be related to the amount of corrosion that occurs during the experiment. A number of different electrical circuits may be used for measuring the resistance changes. Some of these instruments now are available commercially.[2, 4]

Uses for the probe. One of the most important applications of the electrical resistance corrosion probe is in field evaluation of alternative corrosion-protection measures. For example, the probe has been used to evaluate a series of commercially-available corrosion inhibitors for use in a pipestill light naphtha condenser. Fig. 1 presents the results of these measurements. Total amount of corrosion measured on the probe is plotted on the vertical axis, against time on the horizontal axis. Thus, the curve starts at zero corrosion and proceeds to higher values. Slopes of the lines represent corrosion rates.

Differences in effectiveness of these three inhibitors is strikingly apparent. The corrosion rate dropped from .25 in. per year with no inhibitor to .02 in. per year with inhibitor 1 at 11 ppm. When the dosage was increased to 22 ppm the corrosion rate decreased to .01 in. per year.

Immediately after the inhibitor was changed to compound No. 2, the corrosion rate dropped to zero. When the dosage of compound 2 was reduced from 20 to 10 ppm, the corrosion rate increased only to a barely measurable value, .001 in. per year. However, when compound 3 was introduced, at 30 ppm, the rate immediately increased to .08 in. per year.

Measuring iron concentrations ineffective. Fig. 2 shows iron concentrations in the aqueous phase from the light naphtha condenser, obtained during the period of this investigation.

The random nature of these data is apparent from the graph. Note also that although corrosion rate as measured with the probe dropped to zero immediately after inhibitor 2 was added, iron analyses remained high for about two

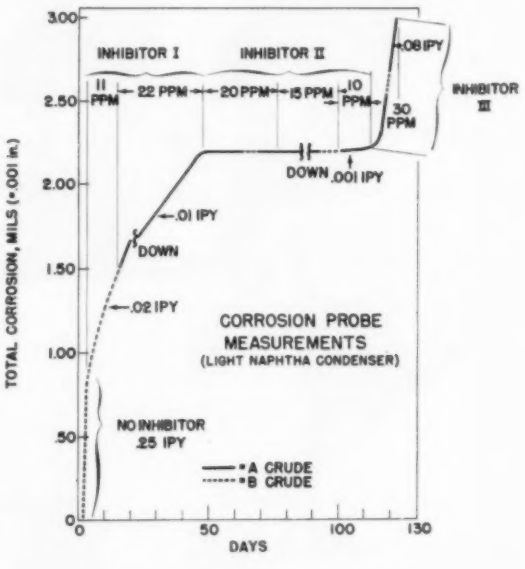

Fig. 1

Abstracted from a paper by the same authors presented before the Refining Industry Symposium at the NACE meeting, St. Louis, Missouri, March 11 through 15, 1957. Published in full in *Corrosion* Magazine, April 1958.

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Good response, good sensitivity, uniform scale. Uses smallest bulb of any filled thermal system.

Class III Gas Pressure (−450° to +1000° F)
Applicable to ranges beyond the limits of other filled systems. Uniform scale. Bulb has long sensitive section; permits useful averaging measurements.

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TEMPERATURE MEASUREMENT AND CONTROL

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weeks. This is a good example of the effects that detergent action can have on metal content of a refinery stream.

Even after low iron counts and clear water were obtained, the data show so much variation that effects of changes in inhibitor concentration are completely submerged. Certainly quantitative comparison of inhibitors cannot be deduced from the iron analyses.

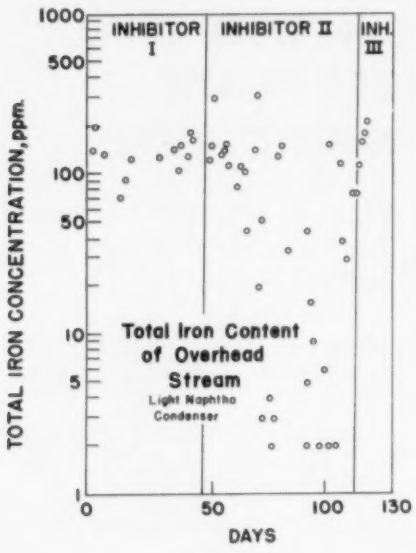

Fig. 2

Effect of process changes. Fig. 3 illustrates the use of the corrosion probe for evaluating effects of process changes upon corrosion rates in a group of pressure stills.

During the first four days of this experiment, the corrosion rate rose steadily as indicated by the increasing slope of the curve. Progressive changes in unit operations were made at times marked by the arrows. After the first change, slope of the corrosion curve decreased to zero. The second change caused an immediate increase in corrosion rate, but control was re-established quickly and the rate returned to zero.

After the third progressive change in operating conditions, corrosion rate gradually increased until experiment's conclusion. The final slope of the curve corresponds to about .44 in. per year corrosion.

Accurate, rapid analysis is valuable. In order to conduct these experiments, it was necessary to measure corrosion rates in high temperature, high-pressure units during normal operations. Any downtime required to change coupons or make caliper readings between operational changes would have introduced additional variables and obscured test results.

In addition, only average corrosion rates between shutdowns could have been obtained. With the electrical resistance corrosion probe, it was possible to observe the effects of changes in operating variables upon corrosion rates almost immediately after changes were made, and to follow closely the variations in corrosion rate with time.

Conclusion. Thus, the electrical resistance corrosion probe provides quantitative measurements of corrosion rates in refinery equipment without interferring in any way with normal operations. With this tool, the corrosion engineer can evaluate rapidly and accurately a series of corrosion-protection measures. He can observe the effects of operational changes and monitor frequently sensitive locations in new units.

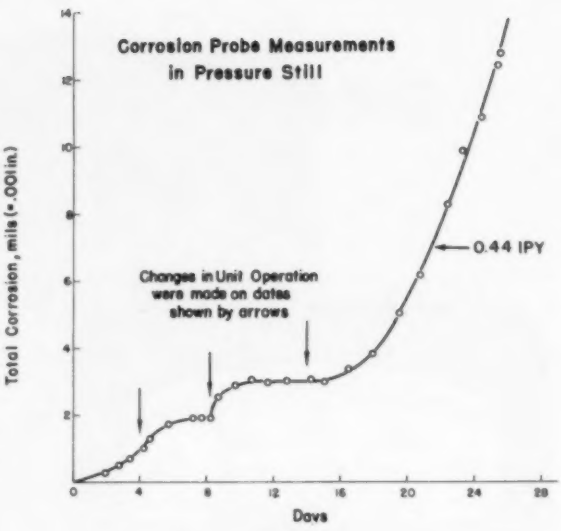

Fig. 3

As refining and petrochemical processes become more complex, the electrical resistance corrosion probe should become increasingly important in corrosion investigations of all types.

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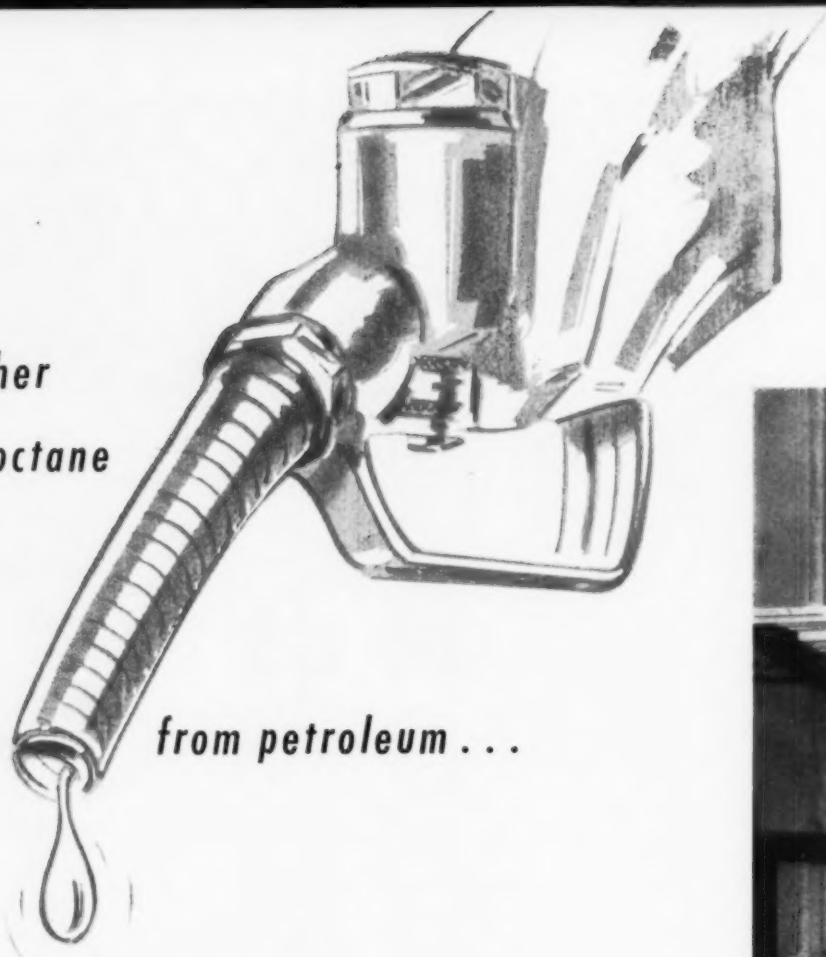

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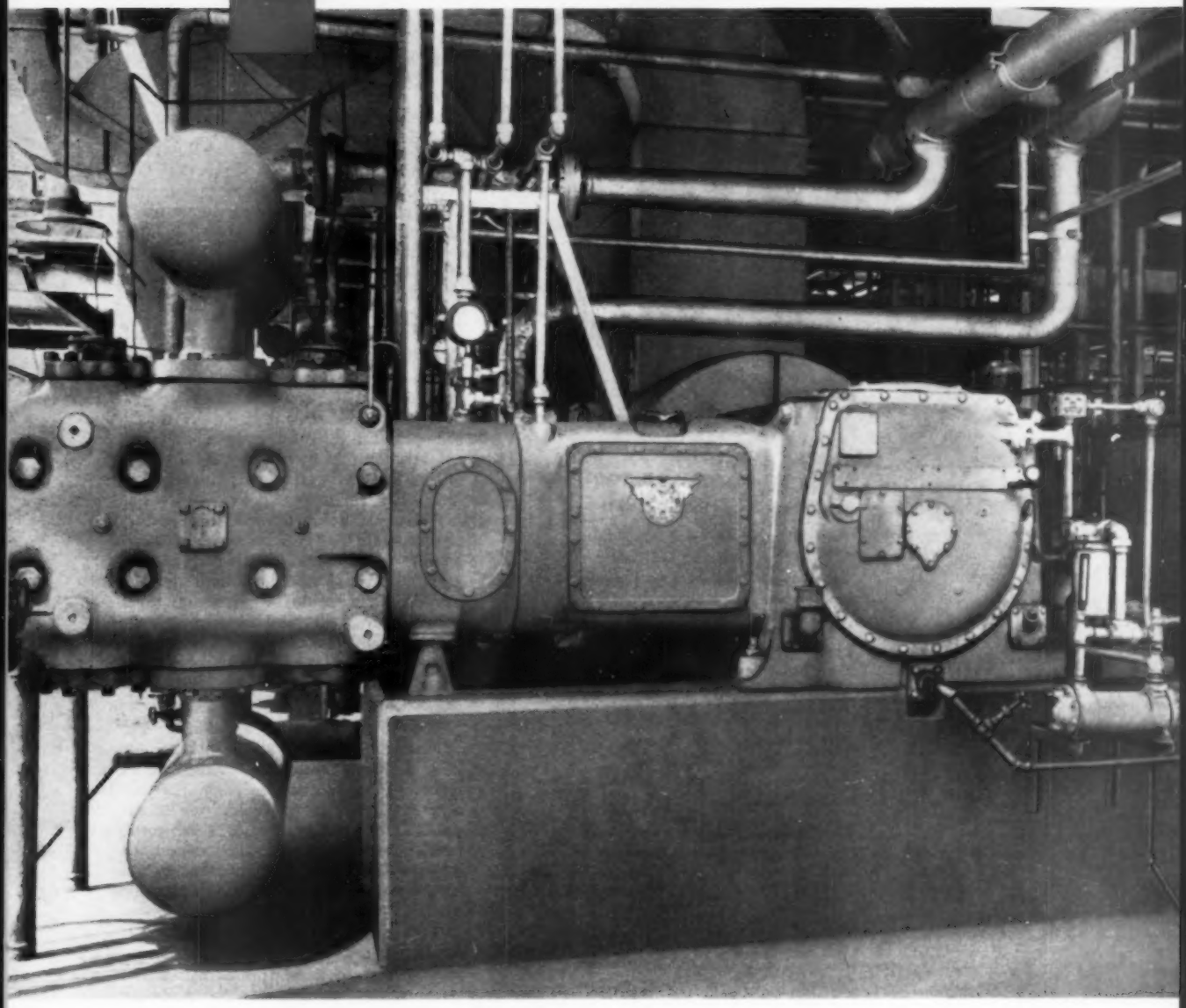

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New UOP Petrochemical and Petroleum Processes Now Available To Refiners

Two new processes, Alkar and Butamer, recently announced by Universal Oil Products Company, offer a great potential for helping refiners secure maximum profits from their operations. Alkar provides the refining industry with a practical means of enjoying the increasing market for petrochemicals with minimum capital investment and profitable operational ratios. Butamer offers the refiner an economical method of securing isobutane.

The Alkar process permits the utilization of the light olefin content of fuel gas on a much larger scale than has previously been practical for the average refiner. The recovery of this by-product olefin from off-gas streams has been frequently impractical because of the very substantial investments necessary for separation equipment. In the development of the Alkar process, UOP worked on the premise that great economies would result if the by-product olefin could be chemically converted without the necessity of prior concentration. The accomplishment of this with the Alkar process now makes it possible for many more refiners to enter the petrochemical field.

The Alkar process is based on the use of a completely new catalyst. This catalyst, in solid form, is used as a fixed bed in reactors of conventional design. The catalyst being non-corrosive, the use of expensive alloys in reactor construction is unnecessary. It is stable against conditions normally encountered in processing and in the handling required in loading the reactors. Catalyst costs are low and special catalyst handling equipment requirements are at a minimum.

Another potential application of the Alkar process provides for the upgrading of fuel gas value olefins to premium octane motor fuel. This is accomplished by the use of the Alkar process to react the olefins with aromatics produced by catalytic reforming.

The Alkar process is but one of a number of petrochemical processes UOP makes available to the refining industry. For many years UOP's research and engineering staffs have been actively developing processes

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Alkar and Butamer processes increase refining profits with minimum investment

which yield valuable chemicals from petroleum raw materials and refinery by-products. To provide a broad range of processes for a refiner's every need, Universal also licenses several processes originated by others. UOP petrochemical processes available to refiners include . . . Catalytic Condensation . . . Olefin Extraction For Butylene Recovery . . . Catalytic Dehydrogenation . . . Hydrar* . . . Udex® (originated by Dow Chemical Company) . . . Two-Stage Unifining* . . . Arosorb* (originated by Sun Oil Company).

The Butamer Process

The Butamer process fills the need for an efficient and economical method for converting normal butane to isobutane. This process is particularly important at this time because of the growing demand for isobutane resulting from the increasing use of alkylate for blending into motor fuels.

This process is the result of extensive UOP research and development to secure an improved normal butane isomerization technique. The accomplishment makes it possible for refiners to have, at minimum capital investment, a practical and profitable means for normal butane isomerization.

The basis of this process is the development of a stable and rugged catalyst, capable of operating at relatively low temperatures. Low temperature operation is essential so that the concentration of isobutane in the effluent from the reactor will be sufficiently high to eliminate excessive recycle of normal butane.

Data obtained with the platinum-containing Butamer catalyst show that temperatures in the range of 600° F. to 850° F. will produce an equilibrium concentration of isobutane in the total butane effluent ranging from 49% to 40%. The process is operated under hydrogen pressure.

A low hydrogen-to-charge ratio is used. The high activity of the catalyst makes it possible to operate the process at economical liquid hourly space velocities. This makes possible a reasonable catalyst inventory.

UOP will be glad to supply, without obligation, individual recommendations for the practical application of its various petrochemical processes to any refining operation, anywhere in the free world.

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The favorable economics of Alkar processing allow application of this technique in all sizes of refineries, thus permitting entry of new operators into the petrochemical field.

Alkar is one of many UOP petrochemical and refining processes available to refiners everywhere. We will be glad to provide full information on this or any other UOP process without obligation.

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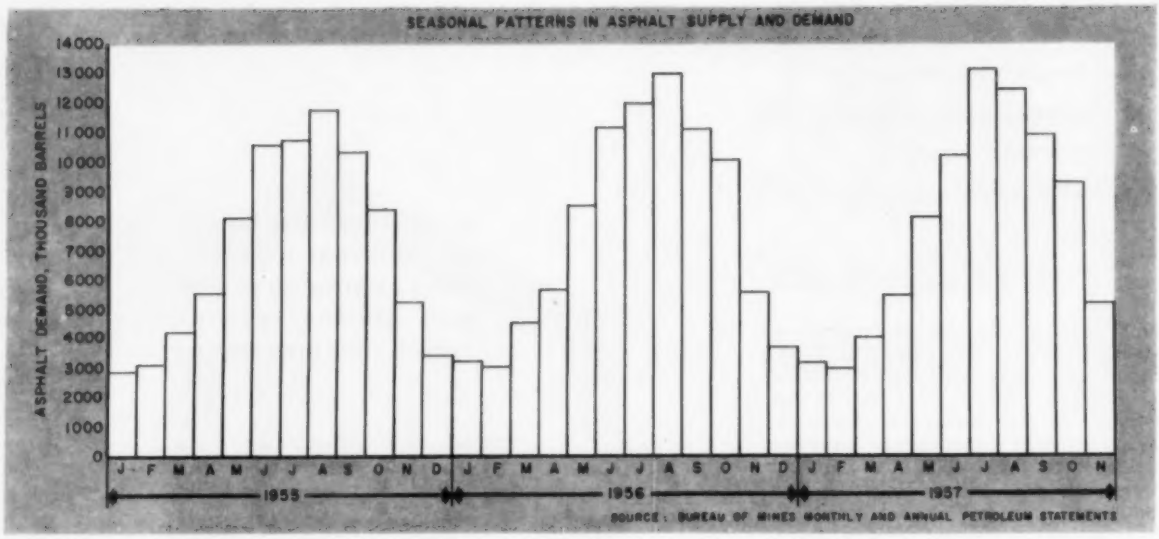

FIG. 1.

The expected surge in demand is just about here . . .

Are Asphalt Producers Ready?

A Refining Engineer survey and market analysis shows up both strong and weak points

S. Whitney Downer III
Editor

ARE REFINERS READY to meet the forecasted increase in demand for petroleum asphalts?

During peak construction years for the Interstate and Defense Highway System, the petroleum industry will be called upon to supply vast quantities of paving asphalts. In addition to this program, primarily financed by Federal Government, state, county and local, road building and repair programs are calling for increasing quantities of asphalt.

Sales for all end uses are predicted to reach 137-million bbl annually during the period 1960-67.[1] As shown in Table 1, this sales level represents a 50 percent boost from 1956, the biggest demand year that asphalt has experienced thus far.

[1] Asphalt Demand — 137 Million Barrels in 1960-67, Herbert O. Jason, *The Refining Engineer*, March 1958, Page C-8.

Because of the importance of asphalt to the refiner's profit picture and the industry's basic responsibility to provide the required volumes as a means of minimizing highway construction costs, *The Refining Engineer* made a nationwide survey of asphalt production capacity expected in the early 1960's. This expected capacity is compared here with demand to show where shortages and oversupply might exist.

Strong spots in the picture. The East Coast, Southwest, Rocky Mountain, and West Coast regions of the country will have more than adequate capacity to meet demand for asphalts in their own areas. The only region that would have considerable excess capacity is the West Coast.

Supply of crude oil should not be a problem. Possible shortages based on a by-products type analysis of supply — detailed later — would be only about 0.5 percent of probable crude runs and a little less than 5 percent of expected residual fuel oil requirements.

The weak points. Definite shortages of asphalt will exist in the Deep South and Midwest (the Dakotas, Minnesota, Wisconsin, and Iowa, primarily) unless large transfer shipments are made from adjacent regions. It is important to note that excess capacity in adjacent regions *can* make up for those areas where potential shortages exist.

TABLE 1. Sales of Asphalts in 1956 Compared to 1960 - 67.
—thousands of barrels annually—

	1956		1960		Growth
Highway construction	64,619	70.74%	56,000		
Highway maintenance			50,000	77.37%	64.0%
"All other"	26,728	29.26	31,000	22.63	16.0
Totals	91,347	100.00%	137,000	100.00%	50.0%

Editor's Note:

This is a condensation of a paper presented by the author to the 46th Annual Meeting of the Western Petroleum Refiners Association, March 24-26, 1958, in San Antonio, Texas.

A complete copy of the report, containing full details on asphalt producing capacity and the derivations of future demand patterns summarized here, will be sent to you on request. There will be no charge. Write to: *The Refining Engineer*, Dept. C, Box 1589, Dallas 21, Texas.

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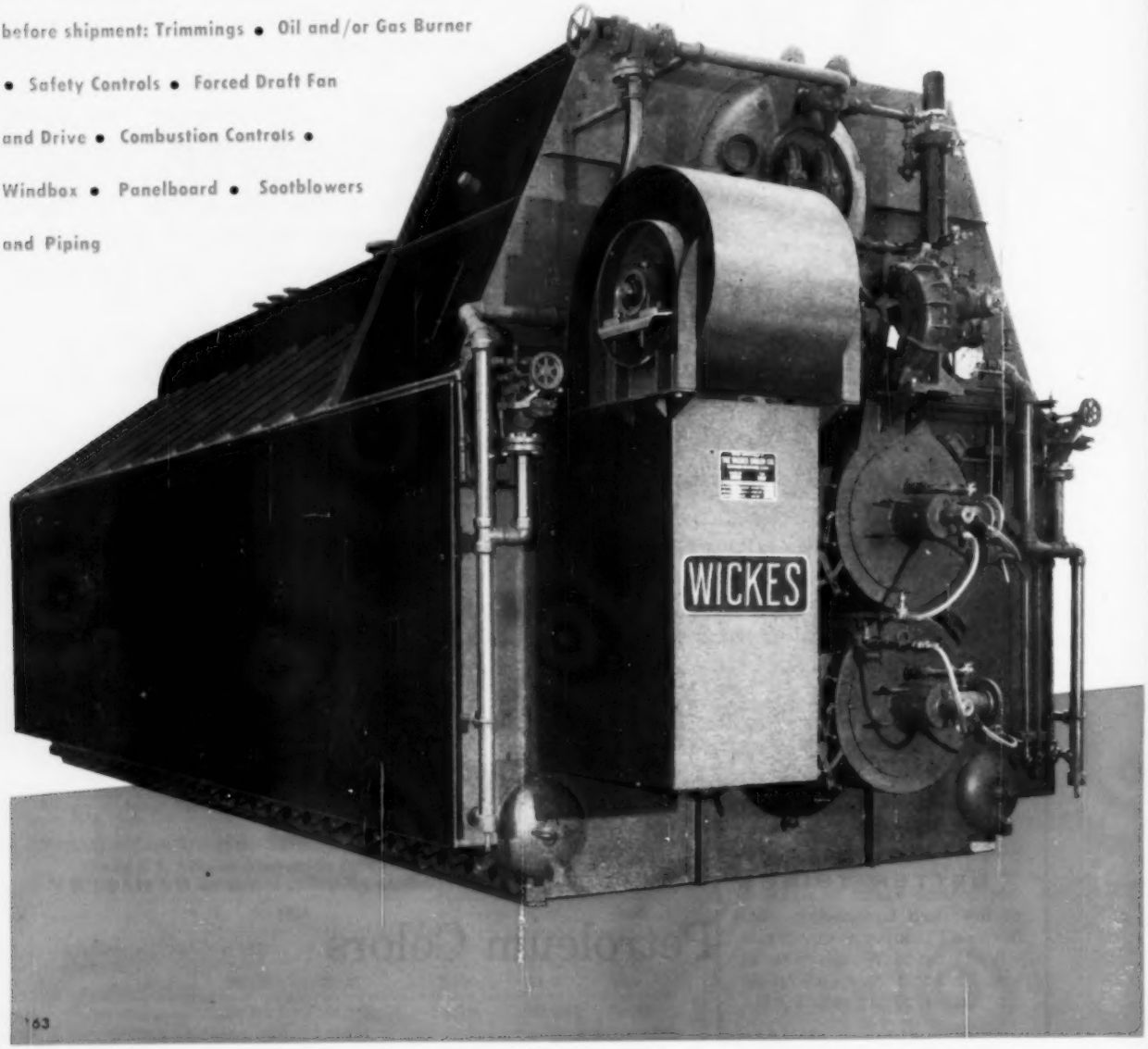

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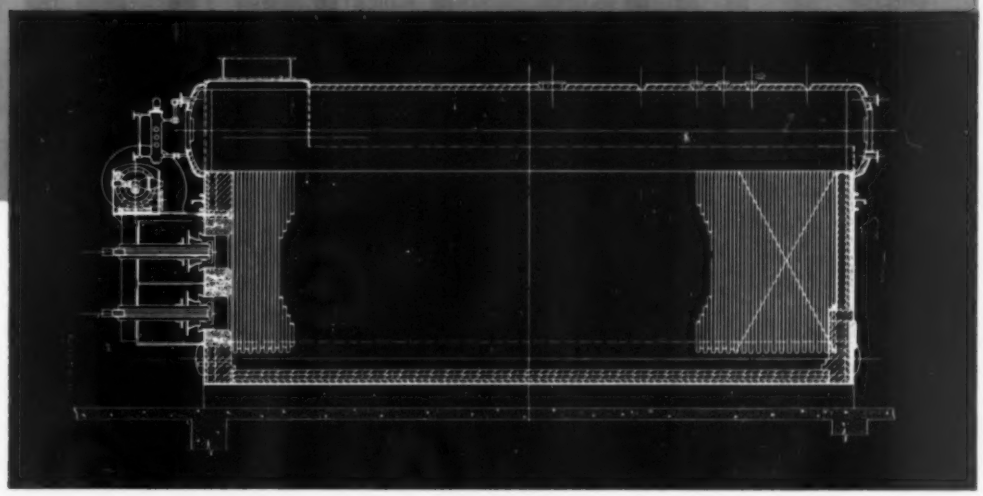

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Based on now-projected capacity, huge inventories of asphalt will have to be built up during the winter months to provide for the peak demand occurring in summer and early fall. Inventories would have to reach better than 31-million bbl just before the paving season starts; more than double the largest volume in storage to date.

An overall picture of asphalt supply and demand can only be provided by a detailed analysis that considers these factors:

1. Seasonal variation in demand.
2. Supply with asphalt considered strictly as a by-product.
3. Correlation of capacity with demand by geographical regions.

Seasonal Variation in Demand, 1960-1967

The only open avenue for forecasting variation in demand is to use historical data.

Sales of all types of asphalt for 1955, 1956, and 1957 are shown by month in Fig. 1. A relatively smooth seasonal pattern is evidenced, with sales lowest in January and highest in August, on the average. Sales in August for these three years were four times higher than sales in January — making asphalt one of the most seasonal of any major petroleum product.

Predicted monthly variations in demand during 1960-1967 is shown in Fig. 2. While calendar-day demand would be 375,000 bbl, stream-day requirements would range from a minimum of 130,000 bbl in January to 650,000 bbl daily during August! Further, it should be noted that the indicated calendar-day demand (375,000 bbl) exceeds by some 34,000 bbl per CD the peak production of asphalt attained to date — 341,000 bbl per stream day in August 1956!

Higher ratio of summer to winter sales in the future is due, of course, to the fact that most of the push in demand is coming from paving asphalts. Paving grade sales are much more seasonal and have a far higher share of market than all other types of asphalts, as shown in Table 1.

Asphalt Production Patterns — By-Product Analysis

As will be discussed in detail later, stream day capacity for making asphalt in the U. S. in the early 1960's will be about 415,000 bbl. To say that this much asphalt could be produced year-'round would, however, be far from accurate. In most refineries, the atmospheric and vacuum distillation equipment that is used to meet peak summer demand for asphalt is used to turn out residual fuel oil in the winter.

Using by-product analysis, it would be legitimate to state that demand for all prime fuel products would fix maximum asphalt production.

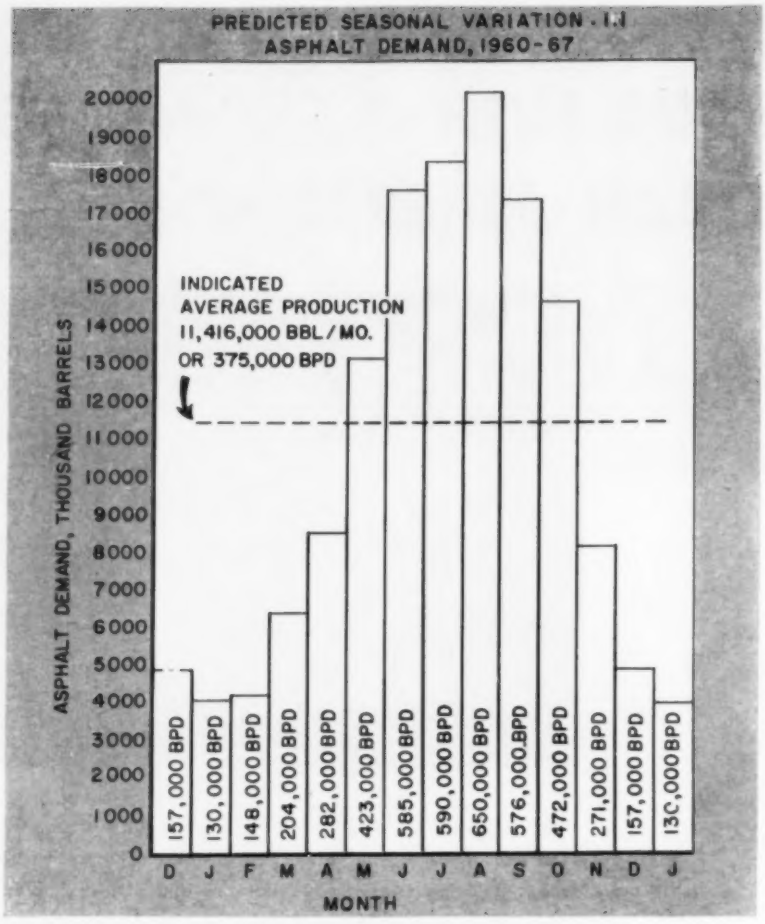

FIG. 2.

The relationship between actual 1956 production, the apparent 1962 production and 1960-67 asphalt demand is shown on Table 2. An apparent shortage of 58,000 B/CD is shown. Furthermore, apparent production during August, 430,000 B/CD, exceeds by 7.5 percent the 415,000 B/CD maximum throughput capacity expected.

This table assumes that asphalt production is governed by demand for all petroleum products. Base year for extrapolation is 1956 for these reasons: First, it is the peak sales year so far for both asphalt and all other petroleum

TABLE 2. Apparent Production of Asphalt Compared to Demand in 1960-67.
(thousand barrels per calendar day)

	1956 Production	1962 production Scaled up from 1956[1]	Demand 1960–67	Apparent shortage/ (excess)
January	143	183	130	(53)
February	163	209	148	(61)
March	192	246	204	(42)
April	221	283	282	(1)
May	260	332	423	91
June	314	402	585	183
July	324	415	590	175
August	341	436	650	214
September	327	419	576	157
October	307	393	472	79
November	219	280	271	(9)
December	158	202	157	(45)
Average	248	317	375	58

[1] Asphalt production by months for 1956 is scaled-up 28 percent to reflect 1952 *apparent* production. This factor is based on a forecast in the January 1958 issue of *The Refining Engineer* estimating total petroleum product demand to reach 11 to 11.5 million bbl daily in 1962 — an increase of 28 percent from 1956.

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products. Second, corrected sales levels are available for that year, but not for 1957.

Although this 58,000 B/CD apparent shortage of supply amounts to about 15.5 percent of expected demand, no insurmountable problems should arise. This "shortage" is a little less than 0.5 percent of probable crude runs and a little less than 5 percent of residual fuel oil requirements.

The deficiency should thus be easily met by one or a combination of several expedients. Some asphalt could be backed out of residual fuel. By running more heavy crudes such as Lagnillas, Bachequero, or Boscan from Venezuela, production could be stepped up without getting into serious oversupply of other products. Or, imports of asphalt could be increased if necessary.[2]

Asphalt Refining Capacity In the United States

During November and December, *The Refining Engineer* made a survey of all known asphalt-producing refineries to obtain an estimate of total capacity in 1960. Results are detailed in Table 3.

Total capacity is expected to be nearly 415,000 bbl per day, comfortably above the expected demand of 375,000 B/CD. But, full utilization of this capacity requires a sufficient volume of the proper crudes and/or enough flexibility to back asphalts out of residual fuel oil. And, other matters as presented in the by-product analysis must be considered.

Comparison of Capacity With Demand by Region

How does asphalt producing capacity shown for the various regions given in Table 3 compare with demand expected in those same regions?

In Table 4, future demand and capacity are compared. Requirements for paving asphalts are based on pro-rata share of the Interstate and Defense Highway system to be built in each region, while distribution of demand for all other asphalts is based on current performance as reported by the Bureau of Mines.

Examination of the supply-demand picture given in Table 4 doesn't reveal anything alarming. Most acute problem would seem to be in the Deep South, with an indicated shortage of 12,000 bbl per day. Most of this shortage exists in Florida and Georgia, both of which are particularly accessible to imports

[2] Imports were not taken into consideration in the above analysis because of their current relatively small effect on U. S. supply. Net imports, i.e., imports minus exports of asphalt, amounted to only 5,750 B/CD in 1956. Self-sufficiency except for imports of specialty crudes, is assumed.

TABLE 3. Asphalt Refining Capacity in the United States, 1960.
—based on nationwide survey by THE REFINING ENGINEER—

Region 1 — Northeast	Total Cap'y, B/CD	% of U. S. Cap'y	No. plants
Massachusetts	20,000		1
New Jersey	21,000		3
New York	6,800		3
Pennsylvania	9,200		3
Rhode Island	6,700		1
	63,700	15.4	11
Region 2 — Middle South Atlantic			
Delaware	1,500		1
Maryland	24,700		3
South Carolina	4,100		0
Virginia	4,000*		1
	34,300	8.3	5
Region 3 — Deep South			
Alabama	14,190		4
Arkansas	6,500		5
Florida	1,000		1
Georgia	5,250*		1
Louisiana	14,200		6
Mississippi	3,460		2
	44,600	10.7	19
Region 4 — Great Lakes Area			
Illinois	19,900		6
Indiana	21,400		3
Kentucky	10,430		2
Michigan	13,250		4
Ohio	23,400		4
Wisconsin	2,800		2
	91,180	22.0	21
Region 5 — Midwest			
Kansas	21,700		9
Missouri	3,800		1
	25,500	6.1	10
Region 6 — Southwest			
New Mexico	1,400		1
Oklahoma	11,944		7
Texas	38,400		11
	51,744	12.5	19
Region 7 — Rocky Mountain			
Colorado	1,750*		1
Montana	9,325		7
Utah	3,700		2
Wyoming	14,450		7
	29,225	7.0	17
Region 8 — West Coast			
California	65,860		18
Oregon	3,000*		1
Washington	5,600*		2
	74,460	18.0	21
Total U. S.	414,709	100.0	123

*Estimated.

TABLE 4. Asphalt Demand and Producing Capacity by Geographical Regions in 1960 - 1967.
— Paving Demand Distributed by Share of Interstate Highway Construction Only—

Region*	Percent of demand			Barrels per day		
	Paving	Other	Total	Demand	Capacity	Long/(Short)
1&2 East Coast	19.8	32.2	22.6	84,700	98,000	13,300
3 Deep South	15.3	14.2	15.1	56,600	44,600	(12,000)
4&5 Midwest	29.0	31.2	29.5	110,700	116,680	5,980
6 Southwest	15.1	8.1	13.5	50,600	51,744	1,144
7 Rocky Mtn.	10.4	1.2	8.2	30,700	29,225	(1,475)
8 West Coast	10.4	13.1	11.1	41,700	74,460	32,760
	100.0	100.0	100.0	375,000	414,709	39,709
Percent of Market	77.37	22.63				

*See Table3 for states included in each region.

TABLE 5. Asphalt Demand and Producing Capacity by Geographical Regions in 1960 - 1967.

Paving Asphalt Demand Distributed by Total Miles Federal-Aid Highways.

Region	Barrels per day				
	Paving	Other	Total	Capacity	Long/(Short)
1&2 East Coast	64,740	27,240	91,710	98,000	6,290
3 Deep South	44,140	12,010	56,150	44,600	(11,550)
4&5 Midwest	120,810	26,390	147,200	116,680	(30,520)
6 Southwest	30,200	6,850	37,050	51,744	14,964
7 Rocky Mtn.	13,940	1,020	14,960	29,225	14,265
8 West Coast	16,850	11,080	27,930	74,460	46,530
	290,410	84,590	375,000	444,709	39,709

Net Capacity Shortage Excluding West Coast — 6820 B/CD.

from Venezuela. Also, there is the possibility of transfer shipments from the East Coast and Gulf Coast refineries.

Unfortunately, excess capacity on the West Coast would be of little help in other parts of the country; high transportation costs would preclude transfers from this area.

More accurate indication of supply-demand balance would perhaps be given by distributing paving asphalt demand by total mileage of existing highways plus those to be built. Reason is that asphalt used for maintenance is about equal to the volume used for new roads.

The Department of Commerce in a recent bulletin has presented a state-by-state breakdown of the 775,000 miles of Federal-aid primary and secondary highways existing or slated for construction. These data represent a majority of our paved roads — in the league of 80 percent.

Table 5 shows the supply-demand picture that results when using this mileage as the distribution base for paving asphalt.

The supply situation here might be cause for concern. Net capacity shortage, excluding the West Coast, would be 6820 bbl per day. Excess capacity on the East Coast would not be nearly enough to cover shortages in the Deep South of 11,550 bbl per day.

Excess capacity in the Southwest (primarily Gulf Coast) would, however, be more than adequate to fill the gap, assuming transfer shipments to be economically feasible.

An area of major concern would be the Midwest. Practically all of the shortage in here would be in North and South Dakota, Nebraska, Minnesota and Iowa, which have no asphalt producing capacity. While part of the 14,300 bbl per day excess capacity in the Rocky Mountain states could cover the deficiency, there might be a large gap between supply and demand.

Effect of Seasonal Variation in Demand on Refiners

Since daily production capacity is much, much lower than demand for peak sales months, it will be necessary that refiners produce in excess of demand during the "lean" seasons to provide for peak periods. This is now common practice, of course.

TABLE 6. Demand, Production and Stocks of Asphalt by Months — 1960-1967.

(excluding West Coast region — California, Nevada, Oregon and Washington)
—thousand barrels per day—

	Demand	Production	From/(to) Storage	E. O. M. Stocks M. Barrels
January 31	115	320	(205)	19,336
February 28	132	320	(188)	24,600
March 31	181	320	(139)	27,901
April 30	250	320	(70)	31,001
May 31	376	341	35	29,916
June 30	520	341	179	24,546
July 31	524	341	183	18,873
August 31	576	341	235	11,588
September 30	510	341	169	6,518
October 31	419	341	58	5,000*
November 30	241	320	(79)	7,370
December 31	139	320	(181)	12,981
	333	333	—	—

*280,000 bbl discrepancy due to rounding production and demand figures.

How will or must asphalt production capacity as predicted for the 1960's be used to meet the increased demand?

Assuming all demand to be met with domestic capacity, estimation is readily made. The West Coast is, however, excluded because of high excess capacity, with the rest of the country just about in balance. It's further assumed that proper crudes are available and that relatively small shortages in one area can be supplied from an adjacent area with excess capacity.

Result are shown on Table 6 — demand averaging 330,000 bbl per day (ex West Coast) uses the same relative month-to-month variation shown in Fig. 2. Holding maximum monthly production to the 341,000 bbl per day capacity reported for this would require that "full capacity" be used six months of the year. During the other six months, production could only be cut back to 320,000 bbl per day, in order to accumulate stocks to meet peak needs.

Inventories would reach a maximum of 31,000,000 bbl at the end of April, assuming a minimal inventory of only 5,000,000 bbl at the end of the six month peak demand season. Lowest point that actual inventory of asphalts reached during the past three years is 5,700,000 bbl, in October 1955. The highest attained is 15,200,000 bbl in May 1957.

What Are Companies Doing Now or Planning to Do?

Not too much at the moment. Of 123 asphalt-producing refineries in the country, only 15 reported plans for construction to increase capacity or modernize present facilities. Of these 15, only 7 mentioned expansion of capacity.

Two completely opposite conclusions could be drawn from this. Either industry is ready to meet increased demand or it is complacent. Probably a combination of both.

Admittedly, the patterns developed herein leave something to be desired for accuracy. However, it's a pretty safe bet that distribution of demand will fall somewhere near the levels shown. Regardless of basis for distributing demand, imbalances are indicated.

Each refiner should, therefore, fully examine the market potential and competitive situation within some distance of his facilities to see if additional capacity, more storage, and more transportation equipment would be justifiable. ★ ★ ★

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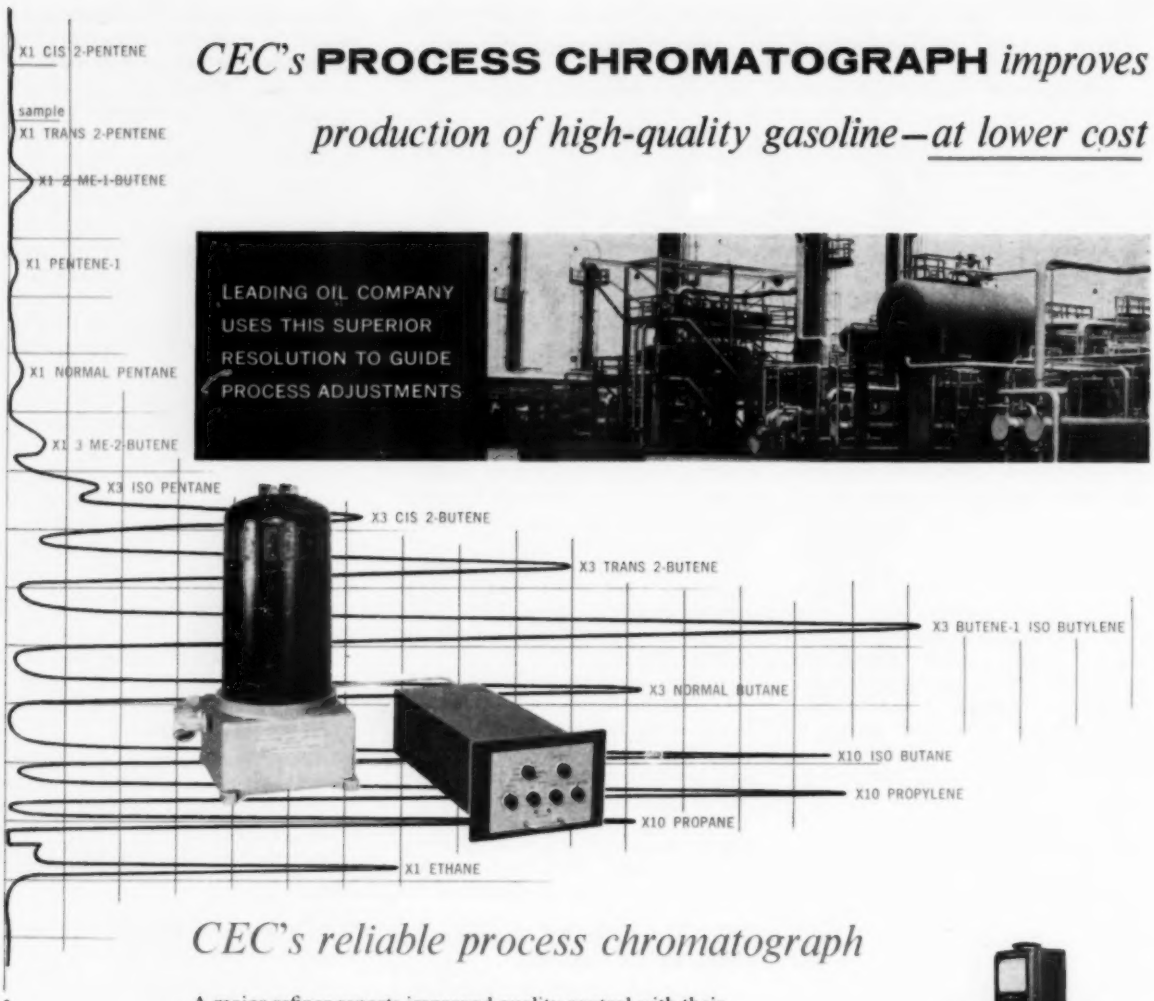

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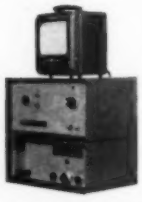

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(Continued from page C-10.)

bility for both 5 Cr-½ Mo and 9 Cr-1 Mo. Carbide agglomeration was the principal structural change resulting from exposures up to 115,000 hours over 1100 F. OD tube surfaces showed no evidence of attack from furnace atmospheres. All ID surfaces showed evidence of carburization.

8. OD and wall measurements of tubes after service retirement established that wall thinning during service occurred from metal wastage at ID rather than OD surface attack from furnace gases. Carburization at ID undoubtedly helped reduce corrosion resistance, thereby increasing ID rate of metal loss.

Compressor Piping Design and Investigations Including Application of Computers to Piping Calculations.

Ralph James, Jr., Humble Oil & Refining Co., Baytown, Texas

Pulsating flow in suction and discharge piping of reciprocating compressors makes necessary special design practices to help provide a smooth running installation having adequate efficiency and low maintenance costs. Two types of phenomena must be considered — periodic mechanical forces and fluid pulsations or acoustic interactions between the compressor cylinder, surge bottles, and associated piping.

Case studies illustrate the effectiveness of special surge bottles or dampeners and orifices in minimizing mechanical vibration from fluid pulsations. In this connection, some associated topics such as piping supports and foundation design are mentioned.

Design procedures are detailed and the applicability of various techniques are discussed. Use of an analog computer to determine the power requirements and the pressure and flow patterns in various parts of an actual compressor installation is also detailed. Comparison is given between the actual installation and the analog results.

Finally, criteria for evaluating the performance of a compressor installation are proposed.

PRESSURE VESSELS SESSION

Presiding: R. E. Lauterbach, vice president and director of manufacturing, General Petroleum Corporation, Los Angeles, California.

[Session developed by N. J. Rees, Socony Mobil Oil Company, New York, New York.]

Experience with Vessels of Delayed-Coking Units.

N. A. Weilt and F. S. Rapasky, The M. W. Kellogg Co., New York, New York

Delayed coking, while continuous as a process, entails periodic accumulation and removal of coke on a 24- to 48-hour cycle. During this period temperature of the coke drums rises from ambient to about 800 F and is then returned to atmospheric. The relatively frequent cycles of this operation magnify effects of pronounced cyclic strains. As a result, numerous instances of equipment distress have been reported, some of which require extensive maintenance and corrective measures.

This paper summarizes the results of an extended survey conducted on 16 delayed-coking units. The most frequently encountered difficulties can be listed as follows:

a. Deformation and growth of shell.
b. Irregular local warping of shell.
c. Cracking of skirt attachment weld.
d. Distortion of bottom manhole-neck flange.
e. Weld cracking between bottom cone and manhole neck.
f. Crack formation around nozzle attachments.
g. Cracking of internal alloy lining.
h. Dishing of the bottom cover.

These sources of various difficulties affecting coke-drum operation were ascertained by an evaluation of data obtained from visits to a number of installations. This information was augmented by analysis wherever possible.

The pertinent findings are presented in the report. A table contains an itemized listing of operating difficulties encountered, their possible source and significance, and the manner of their elimination or minimization on present as well as future installations.

Considerations Involved with the Possible Use of Increased Design Stresses for Pressure Vessels and Their Effect on Safety.

George E. Fratcher and A. F. Cota, A. O. Smith Co., Milwaukee, Wisconsin

(No summary available.)

An Investigation of the Impact Properties of Vessel Steels (A Progress Report).

F. B. Hamel, The Standard Oil Company, (Ohio), Cleveland, Ohio

This paper is a summary of results of impact tests on 161 random samples of new vessel steels. Included is a statistical analysis of the properties of ASTM Specification. A 285C steel, a review of the relative merits of A 285, A 212, A 201, A 204, and A 283 steels, as well as results of computer correlation of the data. In addition, a comparison is made of this data on new vessel steels with similar data on old vessel steels. Of prime interest is the wide variation found in the impact resistance and in the grain size of these specimens.

The following statements are the result of this investigation:

1. A major portion of ordinary vessel steel has very poor impact resistance at *all* ambient temperatures.
2. At low ambient temperatures, most vessel steels have very poor impact resistance.
3. Even though vessel steels are premium steels, the steel fabricators provide little, if any, control on the quality of impact resistance.
4. Grain size is an important factor in impact resistance, yet there appears to be no effort to provide either fine-grain or uniform-grain material.

As Sohio sees the problem, there are three areas that must be covered in order to provide the kind of steel required. These are: Concerted effort by users to establish clearly need for better impact resistance; a *complete* research program to identify *all* factors which control impact resistance; and major effort by the steel fabricators to provide satisfactory impact resistance in *all* steel. The only *sure* way to eliminate low-temperature brittle failures is to provide materials which are ductile at low temperatures. Relying *solely* on design and fabrication quality to prevent low-temperature brittle failures could be dangerous. A single recent major failure had eight separate crack origins, any *one* of which would have permitted complete failure of the vessel.

It is the author's opinion that work should be continued and expanded as a cooperative effort by users of vessel steels, similar to the ship-failure work. This program should have these objectives:

1. Provide a "clearing house" for data on low-temperature brittle failures. (The "little" ones as well as the spectacular ones.)
2. Collect, tabulate, and analyze data, on the impact resistance of vessel and tank material, including the effect of operating time and temperature.
3. Promote improved impact resistance in all steels.
4. Justify improvements in code requirements.

Research and Development — The Catalyst for Steel And Petroleum Progress.

Charles L. Huston, Jr., Lukens Steel Company, Coatesville, Pennsylvania

This paper discusses certain problems relative to development of better steel plate materials for the petroleum industry.

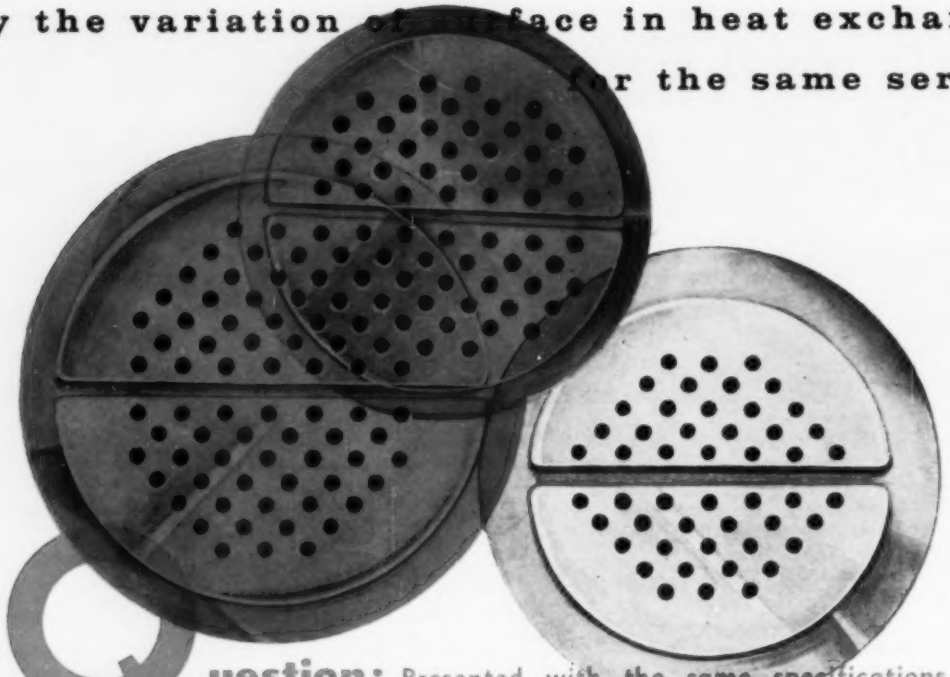
Steel research has been criticized for being too concerned with its own processes and not enough concerned with those of its customers. This criticism may once have been warranted to some extent.

But now under study are these problems of interest: Developing better weldability in A-387 chrome moly steels; production and forming techniques for Hastelloys B, C, and F and titanium in clad steel form; value of ultrasonic testing as an inspection tool; effects of hydrogen on metallurgical properties of clad and alloy steels.

Standard steel specifications may need more prompt and more frequent modification in the future to meet individual customer requirements and permit more rapid development and acceptance of new materials. Every new product must demonstrate potential economic justification in both its market application and its manufacture to merit continuing development; quenched and tempered plate is an example.

Continued and improved cooperation between steel and petroleum will result in better steel research to meet petroleum's needs.

Why the variation of surface in heat exchangers for the same service?



Question: Presented with the same specifications, what justification is there to the variation of surfaces offered by a number of reputable suppliers of heat exchanger equipment, for a given service?

Answer: Since heat transfer calculation to date is not an exact science, the data on which design curves are based may vary over a wide range, and EXPERIENCE is often the deciding factor, SO THAT . . . .

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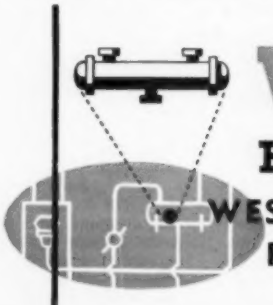
Western specifies the surface to fit your specific service — no more and no less.



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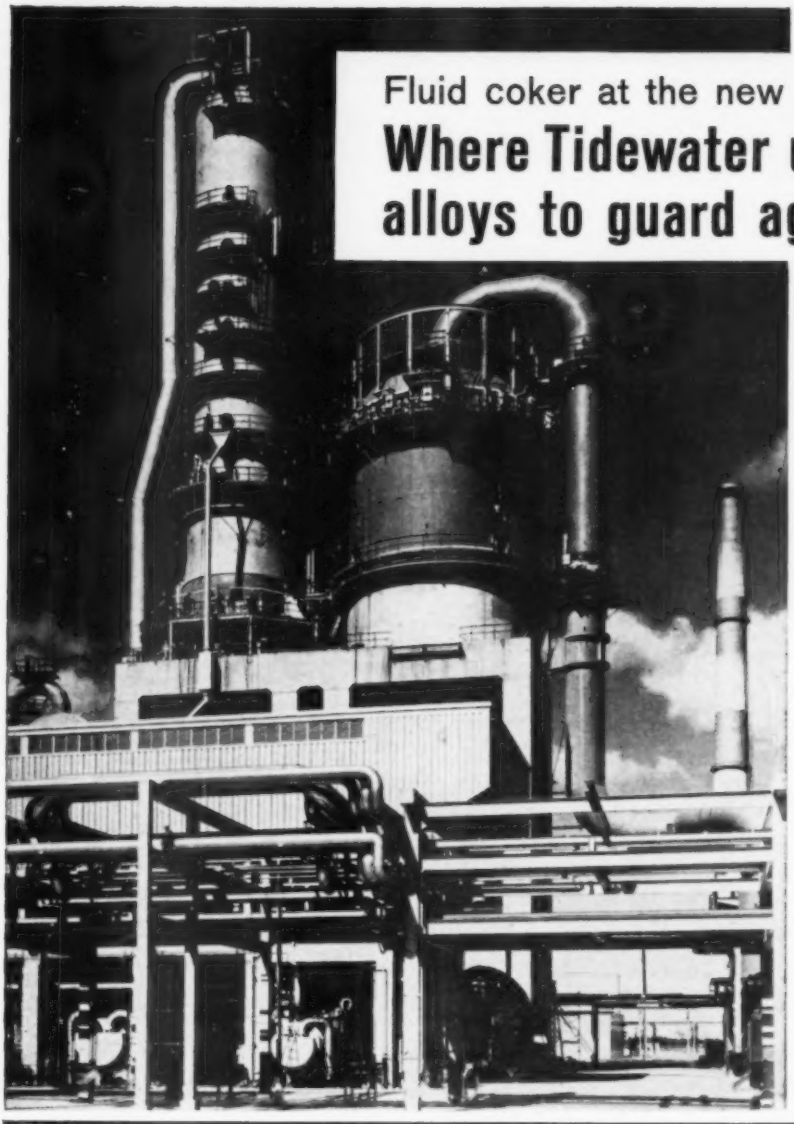

Fluid coker at the new Delaware Refinery...

Where Tidewater uses high nickel alloys to guard against corrosion

Here's the fluid coker at the Tidewater Oil Company's new Delaware Refinery, which boasts the world's largest initial capacity.

Like other units in this refinery, the fluid coker reflects latest practice in economical corrosion protection. To provide this protection, Tidewater engineers took full advantage of the properties of high nickel alloys. You'll find the details in the table below.

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Schedule of Use of Monel nickel-copper alloy to combat corrosion by aqueous H_2S and HCl in fluid coker at the new Tidewater Refinery**

	EQUIPMENT	LOCATION	MATERIAL
Columns:	Fractionator	Top head	Monel-clad steel
		Shell, tray #17 to top	Monel-clad steel
		Trays #17, 18, 19	Monel alloy
Vessels:	Fractionator-accumulator	Nozzles	Monel alloy
	First commingler drum	"	"
	Second commingler drum	"	"
	Stabilizer accumulator	"	"
	Blowdown quench drum	"	Monel alloy
	Main water seal vessel	"	"
	Bypass water seal vessel	"	"
Pumps:	Foul water pump	Casing, impeller	Monel alloy
Piping:	Foul water line, accumulator to stripper		Monel alloy

*Registered trademark **Where temperatures go above 500°-550°F, nickel-containing type 316 stainless and stainless-clad steel are also extensively used in this unit.

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CORROSION SESSION

Presiding: P. N. Gammelgard, vice president for refining, The Pure Oil Company, Chicago, Illinois.

[Session developed by C. H. Samans, Standard Oil Company (Indiana), Whiting, Indiana.]

Mechanism of the Iron-Hydrogen Sulfide Reaction At Elevated Temperature.

Fritz Hugli, Technical University, Winterthur, Switzerland; Charles M. Hudgins Jr., Continental Oil Company, Ponca City, Oklahoma; and Paul Delahay,† Louisiana State University, Baton Rouge, Louisiana

Results of laboratory investigation on the iron-hydrogen sulfide reaction in the range of 427 C to 760 C are reported. These important observations were made:

a. The law of attack is linear.
b. Rate depends markedly on partial pressure of H_2S but not on partial pressure of hydrogen which acts merely as a diluent. Hydrogen can be replaced with helium at the same partial pressure; rate remaining unchanged. (This does not hold true near equilibrium.)
c. Rate of attack is decreased irreversibly by interruption of attack.
d. The film consists of two layers whose thickness ratio remains constant during attack but varies (the thick layer increases) when the metal is completely consumed.

Most of these observations are incompatible with a model based on control by transport of reactants through the sulfide film (Wagner model). It is therefore concluded that a surface reaction is essentially rate-controlling.

Experimental methods for rate determinations, control of H_2-H_2S and He-H_2S mixtures, and analyses of films are described.

Corrosion Experience in Catalytic Reforms With Naphtha Pretreaters.

E. B. Backensto, Socony Mobil Oil Company, Paulsboro, New Jersey, and R. W. Manuel,† Socony Mobil Oil Company, New York, New York

Experience with catalytic reformers having naphtha pretreaters has shown that desulfurization of charge to below 0.002 weight percent sulfur would reduce high-temperature H_2-H_2S corrosion of carbon and low-chromium steels in the reforming section to negligible level. Inadequate desulfurization, caused by pretreater operating difficulties in some cases has permitted scaling in reformers. Such sulfied scale, subsequently exposed to H_2 and low H_2S concenrtations, has been reduced to metallic iron.

Although sulfide scaling in the reforming section is being eliminated in most cases, scaling in the pretreater must also be controlled. Corrosion rates in pretreaters have been, in most instances, approximately as predicted from laboratory data. Sulfide scaling has been prevented by use of 18-8 Cr-Ni stainless steel and calorized coatings.

While sulfide scaling has been minimized, other problems have been encountered. Most serious problems and control methods used are:

a. Corrosion and fouling by chlorides in low-temperature sections of the pretreater. Acid chloride corrosion has been controlled by injection of ammonia and inhibitors and by alloying with Monel. Fouling, as a result of ammonium chloride deposits formed after hydrogenation of organic chlorine and nitrogen compounds in naphtha, has been controlled by continuous or intermittent onstream water washing.

b. Transgranular stress-corrosion cracking of austenitic stainless steel by chlorides. This has been encountered, but is being prevented by washing piping and exchangers with water and dilute alkaline solutions during shutdowns.

c. Intergranular cracking of unstabilized austenitic alloy lining. This occurred in one pretreater reactor, probably as a result of polythionic acids formed by action of wet steam on sulfide scale. This has not occurred in units where stabilized alloys are used and contact of wet steam is avoided.

d. High-temperature hydrogen attack. This has been observed on a few carbon-steel internal details in reactors, but generally hydrogen damage has been avoided by use of chromium and molybdenum steels for exposed parts and by adequate insulation of carbon steel.

Solutions to Corrosion Problems in Light Hydrocarbon Liquids Plants.

J. S. Connors and C. L. Seyer,† Phillips Petroleum Company, Bartlesville, Oklahoma

Corrosion problems commonly found in plants processing light hydrocarbons include corrosion of amine treaters, steam systems, cooling-tower piping, butane-isomerization units, sour-gasoline transfer lines, and finished-product storage tanks.

Corrosion in amine-treating units should always be given serious consideration. Rate of corrosion can be minimized by process-design changes to prevent high-temperature and oxygen degradation of amine, by use of reclaimers, and by stress-relieving of key equipment.

Carbon dioxide is the chief cause of corrosion in steam systems. After application of maximum practical measures for its removal, use of inhibitors will prove profitable.

Cooling-tower piping is subject to severe external corrosion because of alternate wetting and drying under oxidizing conditions. Periodic replacement of water-distribution piping, with possible use of unreinforced plastic pipe, is a solution for this portion of the problem. Cooling-coil-piping corrosion is handled by providing corrosion allowance and by use of an inorganic zinc-dust coating.

Corrosion in butane-isomerization units is mainly the result of action of HCl on impurities in the feed and catalyst. Hastelloy "B" and Monel equipment and tell-tale hole drilling of carbon-steel equipment have resulted in satisfactory corrosion control. Glassed equipment is being tested, appears promising.

CO_2, H_2S, and water are the chief factors in corrosion of sour-gasoline transfer lines. Oxygen will accelerate rate of corrosion. Inhibitors will reduce rate of corrosion and prevent reduction in "C" factor.

Protection of product storage tanks against internal corrosion is often difficult to justify. Upper-shell area of old floating-roof tanks can be economically protected by an abrasion-resistant coating. Tank-bottom protecting systems being used include cathodic protection and thick plastic coatings. Glassed-steel bottoms are also under consideration.

Corrosion Studies in Alkanolamine Systems.

J. D. Sudbury,† O. L. Riggs and J. F. Leterle, Continental Oil Company, Ponca City, Oklahoma

Laboratory studies presented show an unusual corrosion process occurring in aerobic alkanolamine-brine systems. The process, designated filiform corrosion, is an oxygen concentration cell growing in a highly directional manner characterized by formation of long, narrow, hollow, thread-like filaments of corrosion product. Anode, or head of the filament, is fed by corrodent passing through the hollow tube in the tail.

Commercially-available oxygen corrosion inhibitors did not arrest growth. An inhibitor designated "T-52" was developed which successfully controlled filiform and general corrosion in laboratory DEA systems up to 200 F.

Evaluation of this inhibitor in two refinery Girbitol units has been started; preliminary results show a reduction in corrosion rate after inhibitor addition in liquid phase, no reduction in vapor phase. Further results were reported orally.

ANALYTICAL RESEARCH — FIRST SESSION

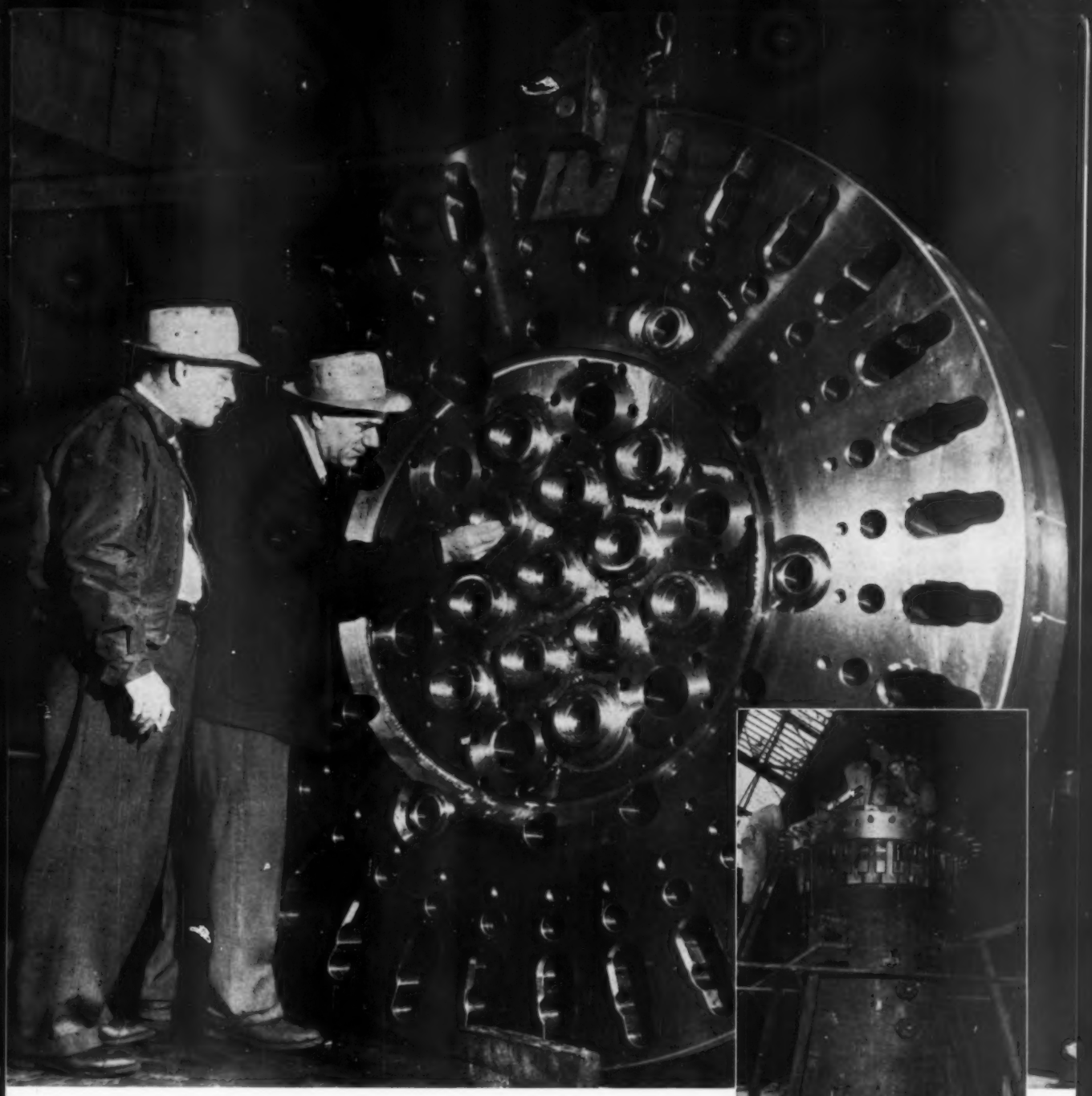
Presiding: F. L. Hartley, vice president for research, Union Oil Company of California, Brea, California.

[Session developed by B. J. Heinrich, Phillips Petroleum Company, Bartlesville, Oklahoma.]

A Mathematical Approach to Operating an Analytical Laboratory (Computer Simulation of Laboratory Operations).

G. V. Dryoff† and F. E. Steidler, Esso Research & Engineering Company, Linden, New Jersey

Esso researchers have now used an electronic brain to simu-



This pressure vessel had to be designed with a closure that would open in 30 minutes, and withstand 1500 psi, 550F. Made of Type 304 stainless, the top head has 34 connections, of which 19 required exceptionally close tolerances for control rods.

FOR NUCLEAR NEEDS of Knolls Atomic Power Laboratory, M. W. Kellogg was given the exacting assignment of designing and producing a 32½-ton "Proof Test Reactor Pressure Vessel". This was an unusually complex task, because of the quick-opening closure specifications, requiring a head with novel design and extremely close tolerance machining.

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late operations of the analytical laboratory. Because of its rapidity, the computer can duplicate a year's operations in about 15 minutes.

Service time and laboratory costs are effected primarily by workload and manpower availability. These factors can be described mathematically and a laboratory "model" programmed into the computer.

Alternate ways of operating can be tried; final analysis of resulting data will indicate the most efficient laboratory operating method.

Automatic Titration of Peroxides in Petroleum Products.

Joseph S. Matthews† and Joan F. Patchan, Gulf Oil Research and Development Company, Pittsburgh, Pennsylvania

Determination of peroxides in petroleum products has been a subject of study for many years. This is due to effects attributed to peroxides such as formation of sediments, gum, color, or odor.

Classical iodometric methods for determining peroxide content are subject to several criticisms when applied to gasoline, oils, and other petroleum products. Perhaps most important is side reactions giving rise to unreliable results. Also, other methods have the shortcoming that they determine only one peroxide type, namely, hydroperoxides.

An improved method, employing an automatic titrator, has been devised for the determination of hydroperoxides and diacyl peroxides. The sample is allowed to react with potassium iodide in a semi-aqueous medium; liberated iodine is immediately and continuously titrated by automatic addition of sodium thiosulfate solution. Thus, iodine is never allowed to exceed a very small value and then only momentarily so that only peroxides are determined.

Method has been used to determine peroxide content of gasoline, jet fuels, oils, alcohols and a number of petrochemicals.

Accurate Determination of Sediment in Petroleum Fuels in the Parts-Per-Million Range.

F. A. Buehler and J. S. Wiberley, Socony Mobil Oil Company, Brooklyn, New York, and J. P. Kirchner, Socony Mobil Oil Company, Paulsboro, New Jersey
(Presented by J. B. Rather, Jr., Socony Mobil Oil Company, Brooklyn, New York.)

Socony Mobil Oil Company is proposing a new method for determining sediment in fuels. It can be applied to gasoline, jet, diesel, and burner fuels. It is useful for filtration and storage stability studies where small amounts of sediment of the order of a few ppm must be measured.

Sediment is merely filtered from a fuel sample and weighed on filter paper made of glass fibers. These filter discs are commercially available and easy to use. Results are more accurate than obtained with sintered glass or asbestos fiber fillers.

Particle size of typical sediment was studied using filtration, centrifugation, and microscopic methods. Glass fiber paper removes particles down to 0.5 microns in diameter, which is fine enough to capture all sediment normally found in fuels.

Another advantage of the glass fiber disc is the low adsorption blank. Other filters with greater surface areas were found to adsorb soluble materials from the fuel, tending to give high results.

Socony is using the method and claims a standard deviation of about one milligram per liter between laboratories.

Induction Furnace Speeds Catalyst Analysis: Fluorine, Sulfur, Chlorine, and Bromide.

Anne L. Conrad,† Jean K. Evans, and V. Frances Gaylor, The Standard Oil Company (Ohio), Cleveland, Ohio

A high-temperature induction furnace used to speed catalyst analyses is discussed. Intense heat generated in the induction coil achieves rapid combustion of stable catalysts, with temperatures of about 1400 C obtained.

At these conditions, catalyst is completely decomposed and all volatile constituents trapped as they evaporate from the melt.

Materials such as sulfur, chlorine, bromine and fluorine have been determined in this manner.

Determination of Microgram Quantities of Sulfur By Reduction with Raney Nickel.

Lawrence Granatelli, American Oil Company (Texas), Texas City, Texas

The petroleum industry repeatedly tests raw materials and products for sulfur content. Sulfur is harmful to equipment and inactivates certain petroleum catalysts; even minute amounts are harmful. A reliable method for determining one or two parts of sulfur in a million parts of sample has been needed for many years.

The method developed for the first time allows the reliable determination of less than one part of sulfur in a million parts of sample. Specially prepared nickel catalyst is used to convert sulfur in the sample to nickel sulfide. Established methods of analysis determine sulfur in the nickel sulfide; the analyst can then calculate sulfur content of the sample.

Quantitative Analysis of Mono- and Polybasic Benzene Carboxylic Acids in Potassium Bromide Disks by Infrared Spectroscopy.

D. E. Nicholson, Humble Oil & Refining Company, Baytown, Texas

A number of refineries are now producing raw chemicals from which textiles and plastics may be ultimately produced. These raw chemicals are first converted to intermediates from which finished products are made.

Meticulous research has established that properties of polymers and textiles can be influenced very markedly by only small changes in chemical structure of some intermediates. A number of analytical techniques have been employed in characterizing these compounds. Some difficulty has been encountered by use of more conventional methods with the mono- and polycarboxylic acids.

In attempting to make these determinations, a comparatively new and little-used technique was employed which ultimately proved very satisfactory after much developmental work.

In this technique the solid sample is compressed with potassium bromide into a pellet. When placed in an infrared beam, this pellet can give information related to its contents by study of the transmitted infrared light.

This study also resulted in certain general findings which make this technique applicable to other materials.

Microcarbon and Hydrogen Determination by Automatic Combustion Control.

Ervin Stehr, The Texas Company, Beacon, New York

An efficient micro method has been developed for determining carbon and hydrogen automatically. As in the conventional method, carbon and hydrogen are converted to CO_2 and water by combustion, but manual control of combustion is replaced by an automatic process.

Burning of the sample is controlled by pressure increases developed by the combustion itself. A movable heater passes over the sample, causing vaporization and production of gaseous products, building up the pressure within the combustion tube. When pressure reaches a predetermined maximum, heater movement is stopped until the pressure is dissipated by diffusion of gases through a choking plug. Rate of sample flow through the combustion tube is thus automatically controlled by electrical and mechanical devices.

This method allows the operator more freedom during the combustion period, results in greater production. Another advantage is more precise control, allowing more consistent results.

Determination of Surface Area: Adsorption Measurements By a Continuous Flow Method.

F. M. Nelsen† and F. T. Eggertsen, Shell Development Company, Emeryville, California

A promising new method has been developed for measuring adsorption of nitrogen in determining surface area of solids.

Nitrogen from a continuous gas stream of nitrogen and helium is adsorbed by the sample at liquid nitrogen temperature then eluted by warming. Nitrogen thus liberated is determined by thermal conductivity measurements on the exit gas stream.

Close agreement is obtained with the conventional volumetric method for surface area measurements by nitrogen adsorption, and precision appears equally good.

Chief advantages of the new method are: It does not involve vacuum techniques, is therefore free of concomitant maintenance problems; it is simpler for routine application; and, permanent record is automatically obtained. Also, method can be applied to samples of lower area — down to about 0.1 sq m/gm.

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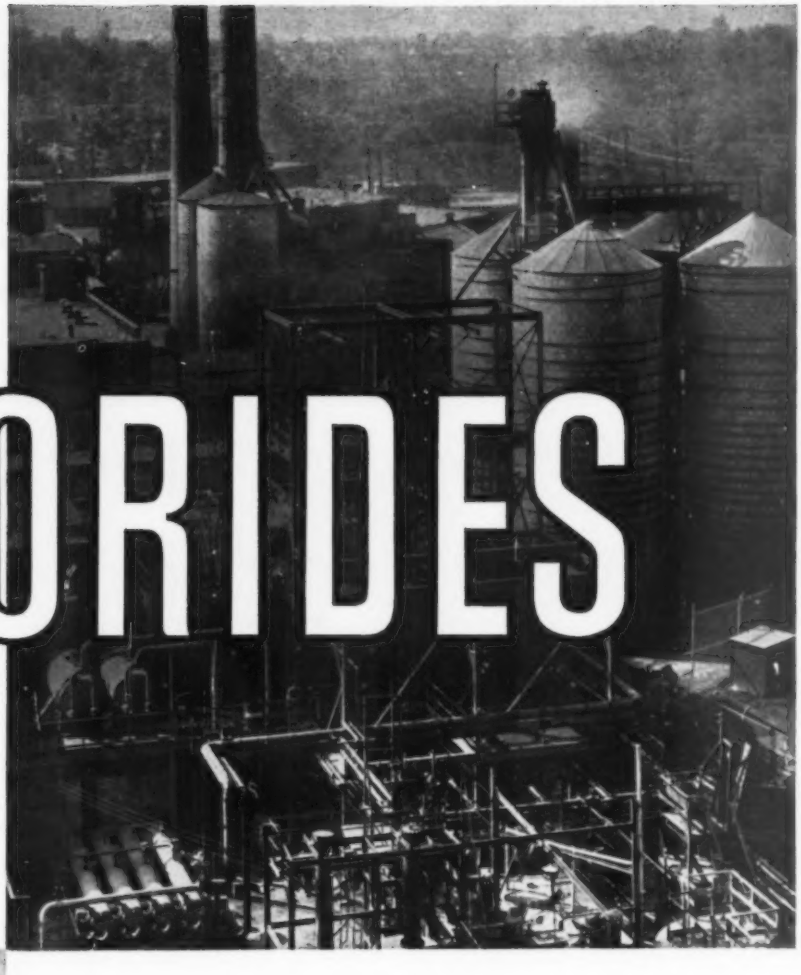

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ANALYTICAL RESEARCH — SECOND SESSION

Presiding: C. A. Day, manager of research and development, Richfield Oil Corporation, Anaheim, California.

[Session developed by B. J. Heinrich, Phillips Petroleum Company, Bartlesville, Oklahoma.]

A Photometric Titrator and Method for the Determination of Bromide Numbers with Electrogenerated Bromine.

John W. Miller, M. D. Grimes, and B. J. Heinrich,† Phillips Petroleum Company, Bartlesville, Oklahoma

A new instrument for determination of bromine consumption of petroleum products has been developed by Phillips Petroleum.

Since refinery streams contain increasing amounts of olefins, this is an analysis of considerable interest; this new instrument is now being used to measure olefins in experimental products.

The instrument is based on the fact that bromine will react selectively with olefins in the presence of other hydrocarbons. Bromine is added to the sample of electrolyzing a solution of potassium bromide, forming elemental bromine. The bromine is consumed as rapidly as produced as long as there is any olefin remaining in the solution. When all of the olefin has reacted, the bromine gives a yellow color to the solution. Appearance of color is detected by decrease in transmission of ultraviolet light through the solution. A sun battery is employed to measure this decrease in transmission of light.

Exact concentration of bromine is read from a recorder attached to the sun battery and amount of bromine consumed is read directly from the recorder chart.

Variable Influence of Automotive Fuel Type On Exhaust Composition.

R. W. Hurn, U. S. Department of the Interior, Bureau of Mines, Bartlesville, Oklahoma

Type of fuel burned by an engine affects exhaust composition in varying degrees, depending upon engine condition, engine operation, and other unknown factors. Work reported was done to obtain factual data about chemical differences in exhaust products from different fuels and how these differences are affected by engine speed and load.

Experimental data were obtained using a late-model V-8 engine on a dynamometer block. Fuels included pure isooctane, commercial LPG (butane and propane, separately), and five gasoline stocks from different refining processes.

Data obtained by gas chromatography show that exhaust composition varies with engine speed and load according to consistent trends. These trends are influenced by fuel composition. Degree of fuel influence depends upon mode of engine operation; some basic fuel characteristics are more heavily reflected in exhaust than are others. Generally, differences in the composition of exhausts from different fuels are quantitatively small. But, they are reproducible.

These data cannot be construed as indicative that fuels do — or do not — differ in smog-forming potential. They outline chemical differences for the use of others who may determine which chemicals in exhaust are important and study measures to make exhaust gas ineffective as a smog producer.

Quantitative Determination of Platinum in an Alumina-Base Reforming Catalyst by X-Ray Spectroscopy.

Arnold J. Lincoln,† Engelhard Industries, Inc., Newark, New Jersey, and Elwin N. Davis, Sinclair Research Laboratories, Inc., Harvey, Illinois

Reforming processes have brought about widespread use of catalyst containing platinum metal. In buying and selling this product, knowledge of exact platinum content becomes of extreme importance. For example, an error of 0.01 percent in determining platinum content on total charge to a typical reforming unit will mean about $10,000.

This paper describes an X-ray spectrographic method for making rapid and accurate determination of platinum reforming catalyst. An analysis can be completed in about three hours, about thirty minutes of which requires the operator's attention. Data presented show precision to be about ± 0.003 percent platinum.

Improved Flame Photometry by Direct Recording Study of Selected Flame Area Emission.

H. D. DuBoise and R. E. Barieau,† California Research Corporation, Richmond, California

Many flame photometric analyses are most easily conducted with sample dissolved in a hydrocarbon solvent. When such a solvent is burned, the flame emission contains strong bands due to the C_2, CH and OH radicals. These frequently interfere.

This paper describes the quantitative aspects of selected area emission and shows the advantage gained by masking an appropriate portion of the flame.

Burners produce diffusion flames whose properties vary widely along length and breadth; this study is concerned with lengthwise variation.

It was found that radiation by C_2 and CH came almost entirely from the lower portion of the flame. Peak emissions of metals such as Na, Ca, Pb, B, and Ba occurred in the upper part of the flame. Therefore, by observation of the upper part only, metal emission detected is free of interference by C_2 and CH. Fortunately, the emission by OH, which cannot be so easily avoided, occurs only over a small wave length region.

WASTE DISPOSAL SESSION

Presiding: K. E. Kingman, vice president-manufacturing, Union Oil Company of California, Los Angeles, California.

[Session developed by J. H. Easthagen, California Research Corporation, Richmond, California.]

The Design of Smokeless, Nonluminous Flares.

P. D. Miller Jr.† and H. J. Hibshman, Esso Research & Engineering Company, Linden, New Jersey; and J. R. Connell, Imperial Oil Company Ltd., Sarnia, Ontario, Canada

The multijet flare, developed by Esso Research and Engineering Company, has proved to be an excellent solution to the problem of conspicuous flaring. One installation has been in service for over a year; additional units are being designed for use throughout the world.

The multijet is a ground flare which burns with no smoke and no noise; its flame is shielded by a 32-ft-high stack. Auxiliary utilities such as steam or water are not required.

The burner consists of scores of vertical jets arranged in a grid pattern. A simple empirical design procedure predicts proper spacing and number of jets.

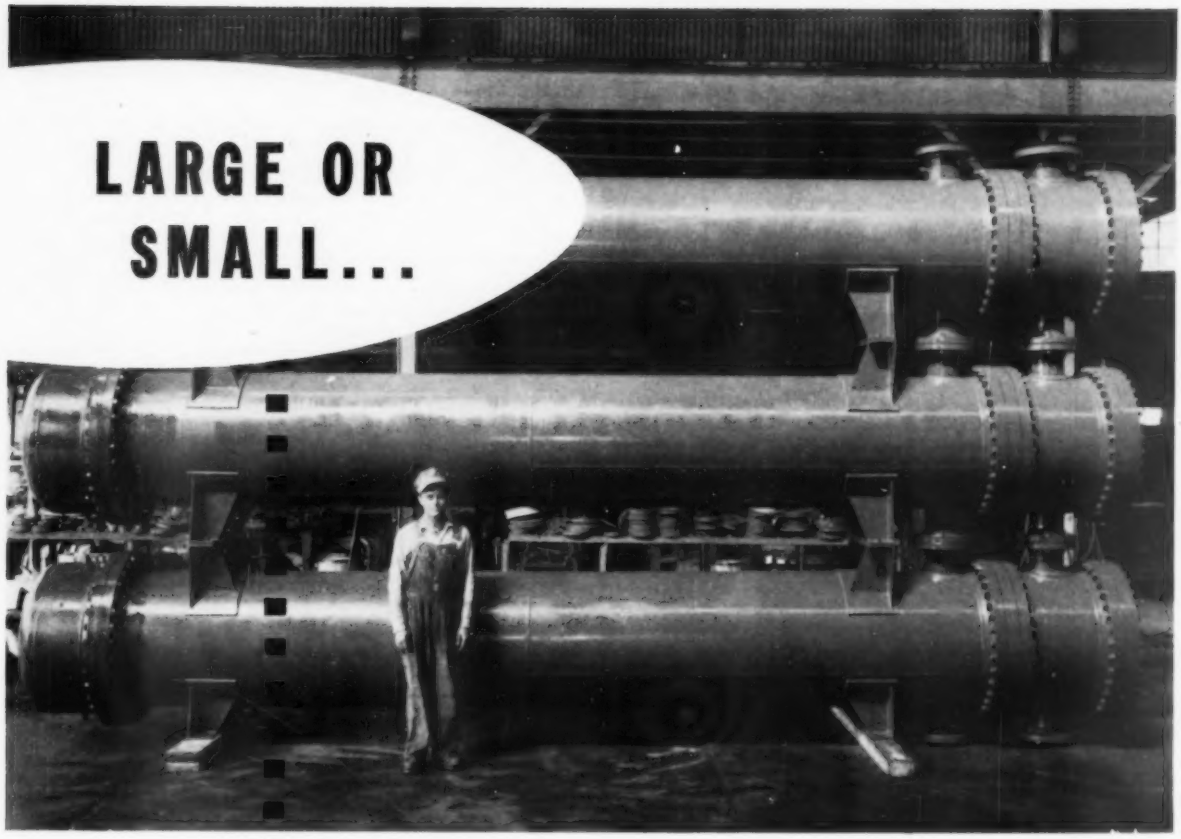
The flare stack is a steel shell lined with refractory material; base of the flare is several feet above grade and contains one or more rows of multijet burners.

The multijet burners are of simple design. They consist of a series of parallel pipes, or "burner lines," which traverse the bottom of the stack; each burner line contains a row of small nozzles discharging vertically into the stack. Solid rods of refractory material are mounted above and parallel to the burner lines. The flared gases impinge against this rod, or "flameholder," before they reach the ignition zone. During this period, enough air is mixed with the gas to give smokeless combustion.

For most cases it is economical to size the flare to handle 95 percent or more of all occurrences of flaring without the appearance of smoke and flame.

Compared with steam injection to elecated flares, the multijet is a far more effective and considerably cheaper method of eliminating smoke and light. The flare is quite flexible; it can be designed to handle almost any desired range of maximum to minimum flaring rate. The multijet requires little or no attention after initial adjustments.

The paper presents complete design details of the flare as a contribution to industry.



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Pollution Control at Ferndale, Washington.

E. K. Daniels,† Los Angeles, California, J. R. Lutz, Ferndale, Washington, and L. A. Castler, Torrance, California. All with General Petroleum Corporation

Pollution control at the Ferndale, Washington, refinery of the General Petroleum Corporation involves the design and operation of the various processes used to control liquid and airborne wastes. The methods of water disposal chosen were dictated by stringent requirements set up by a state agency.

The refinery has six separate and distinct sewer systems to accommodate the various types of wastes. These systems are: oily process waste, sanitary waste, phenolic process waste, normal storm drainage, emergency storm drainage, and ships' ballast discharge. Wastes handled in the first three of these systems are subjected to biological oxidation to reduce phenols. Pretreatment of the various waste streams is essential in order to provide as uniform a feed as possible to the final biological-oxidation waste-water treating equipment.

Total cost of pollution control facilities has amounted to approximately $3,000,000.

Every opportunity is taken to regenerate alkaline solutions used in treating petroleum products, enabling reuse of these solutions and providing further reduction in load to the biological-oxidation units. When strong spent caustic and potassium cresylate treating solutions are no longer effective, they are enriched with the addition of excess hydrogen sulfide or cresylic acids, respectively, prior to sale. Use of stripped hydrogen sulfide gases in the spent caustic sulfiding tower has helped to reduce the quantity of this gas that has to be burned and, consequently, has reduced the emission of sulfur dioxide to the atmosphere.

Floating-roof tanks are used extensively at the refinery to conserve hydrocarbons and reduce emissions to the atmosphere.

Modern Waste Disposal Facilities at Shell's Anacortes Refinery.

E. D. Nuemann and G. J. Reno,† Shell Oil Company, Anacortes, Washington, and L. C. Burroughs, Shell Oil Company, New York, New York

In planning for a refinery in the Puget Sound area, Shell Oil Company chose to treat its waste water by a novel arrangement of known treating equipment.

All areas subject to oil spill and contamination drain to an oily water sewer. A two-channel API-type oil-water separator removes most of the oil from the waste water. Clarification and additional oil removal are accomplished by two primary clarifiers employing alum and activated silica as flocculating agents.

Prior to biological treatment, effluent from the sanitary sewer septic tank joins the de-oiled and clarified water which contains a chemical oxygen demand including phenols and sulfides. Biological treatment, accomplished by trickling filter and an activated sludge basin, is followed by clarification prior to ponding.

Chemical, biological, and silt-type sludges are mixed, thickened, filtered, and calcinated to a sterile ash.

Spent chemicals from treating processes are barged to sea.

After intermediate ponding to effect partial neutralization, washes from ion exchange demineralizers enter the storm flume along with waters from all areas which are not subject to oil spill and do not require treatment. Treated and untreated waters are ponded in a retention system to provide for laboratory examination, retreatment if necessary, and subsequent disposal to the waters of Puget Sound on outgoing tide for maximum dispersal. These treatment facilities have produced effluent which has continuously met rigid requirements of the Washington State Pollution Control Commission since refinery startup in late 1955.

AIR POLLUTION SESSION

Presiding: David E. Day, vice president in charge of manufacturing and pipelines, Richfield Oil Corporation, Los Angeles, California.

[*Session developed by C. A. Jones, Shell Oil Company, Wilmington, California.*]

Investigations to Detect the Atmospheric Conversion of Sulfur Dioxide to Sulfur Trioxide.

Albert L. Chaney, Albert L. Chaney Chemical Laboratory, Inc., Glendale, California

In the gaseous state, sulfur dioxide is only very slowly oxidized to sulfur trioxide. It has been recently suggested that in presence of fog and particulate-matter catalysts, this oxidation may be greatly accelerated. If oxidation does occur, both sulfate and acidity of the particulate matter should increase. Because nitrate is frequently also present in significant quantities, its relationship to acidity should also be known.

Techniques have been developed for testing this hypothesis in the Los Angeles area. Particulate matter was collected and weighed in two separate fractions, based on particle size, and aqueous extracts prepared for determination of acidity, sulfate, and nitrate.

Larger particles were collected by dry impingement and the submicron size by filtration through membrane filters. Fog droplets, if present, would be in the first fraction.

Simultaneous sampling for sulfur dioxide concentration was carried out by a highly sensitive and specific procedure. The sampling period was one hour, with provision made for automatic collection of several successive samples at intervals throughout a 24-hour period.

These samples were sufficient for measurement of both total weight and weight of the water-soluble fraction. Chemical determinations in the microgram range were used for sulfate, nitrate, and acidity measurements.

The general techniques used may be extended to include determination of a number of other constituents of particulate matter as well.

In this investigation the sulfur dioxide was usually very low in concentration and was not well-correlated with sulfate levels. Other sources besides sulfur dioxide may be required to account for the sulfate levels found in the particulate matter. A large fraction of the particulate matter was found to be water soluble, particularly in the submicron fraction, and it contained acidity which could not be accounted for in terms of sulfate and nitrate levels found.

Results are evaluated in comparison with meteorological and released data.

Oxidant Plant Damage from Ozone-Olefin Reactions.

Ellis F. Darley† and John T. Middleton, University of California, Riverside, California; Edgar R. Stephens, The Franklin Institute, Philadelphia, Pennsylvania; and Philip L. Hanst, The State University, Columbus, Ohio

Oxidant plant damage from ozone-olefin reactions at low concentrations was studied in a dynamic stirred flow system incorporating a plant exposure chamber with a long-path infrared spectrometer. Reaction time and concentration of the fumigants were found to be as important, or perhaps more so, than olefin structure in determining formation of the phytotoxicant. Thus 2-pentene and ozone, at 1 to 10 ppm and 1 ppm, respectively, caused no damage at a reaction time of 19 minutes, but did cause damage when the reaction time was reduced to 2 minutes, or at 12 minutes when the concentrations were increased to 10 ppm and 15 ppm, respectively. Although specific reaction products have not caused plant damage, certain hydroperoxides may be involved. The addition of propylaldehyde or sulfur dioxide to 1-hexene-ozone reactions and acetaldehyde to 1-pentene-ozone reactions did not prevent plant damage. The life of the phytotoxicant from 1-hexene-ozone reactions is relatively short — probably less than 30 minutes and perhaps as short as one minute.

Effect of Engine Operating Variables on Exhaust-Gas Composition (A Report on Behalf of the Coordinating Research Council, Inc.).

James M. Chandler, Ford Motor Company, Detroit, Michigan

(No summary available)

TRAINING SESSION

Presiding: Robert E. Yancey, vice president-manufacturing, Ashland Oil and Refining Company, Ashland, Kentucky.

[*Session developed by G. B. Stone, Union Oil Company of California, Rodeo, California.*]

Problem Recognition in Business.

Laurence de Rycke, Occidental College, Los Angeles, California

In a capitalist economy private business concerns must make sufficient profit to retain capital already committed and to attract additional capital if necessary. This objective must be sought within the framework of the prevailing business, legal, and cultural environment.

Basic business problems arise when the pursuit of profits interferes with one or more of these concepts. Questions are posed in the paper to help ferret out the problems.

The Expanding Scope of Executive Development.

Robert Francis Smith, consultant, Los Angeles, California

Progress in improving vocational aspects of executive training — on the job and through special courses and seminars — is encouraging. Success in that area is releasing more top management attention to the non-technical part of an executive's development: his growth as a broadly educated person, equipped to make management decisions that are likely to become judgments of a more qualitative than quantitative nature in the decades ahead.

Efforts to expand background and widen point of view of key policy-making people appear to be coming none too early as problems of management gain in complexity and in importance to society. This development is viewed here in three ways: in its dependence on a self-start; concentration upon liberal arts study; and continuous time dimension ("lifelong learning").

Hoped-for outcome of such an expanded scope in executive development is "bigger man to cope with bigger problems."

All claims, conclusions, etc., set forth in these summaries are at least a portion of those presented in preprints of the papers scheduled for presentation. Publication herein does not constitute, in any manner whatsoever, endorsement or verification by the editors of THE REFINING ENGINEER.

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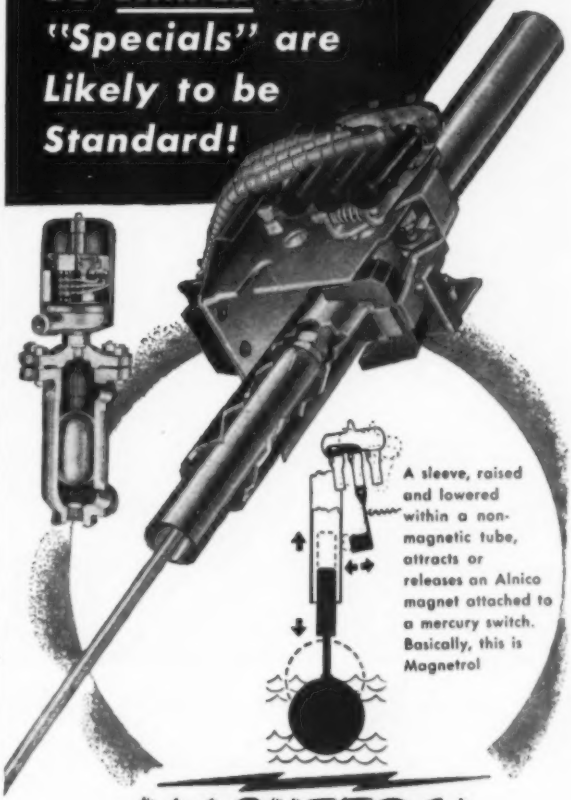
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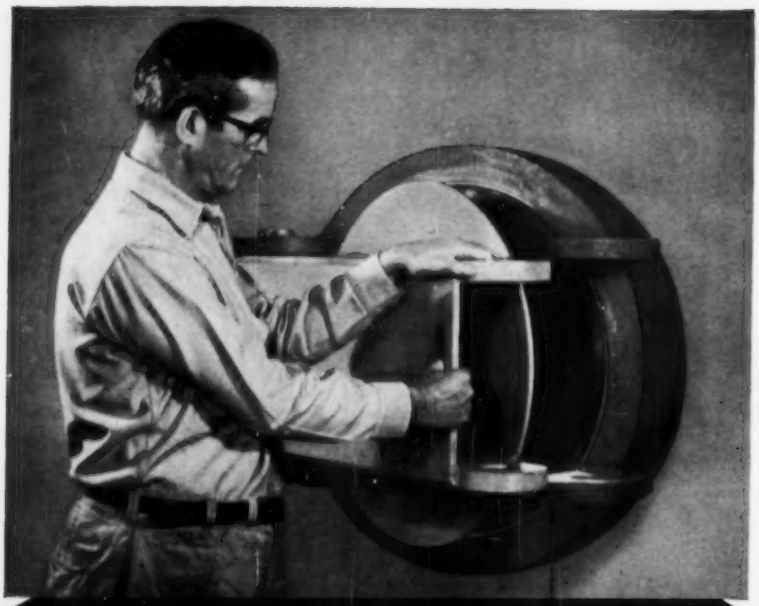

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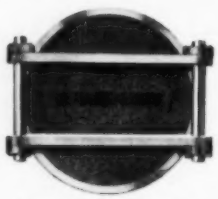

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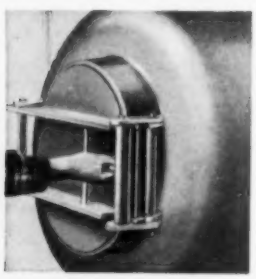

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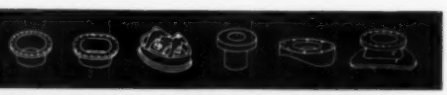

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Refining Books to Read

API Standard 600, Specification for Flanged and Butt-Welding-End Steel Gate and Plug Valves for Refinery Use. *Fourth Edition. Published by the American Petroleum Institute, 50 West 50th Street, New York 20, 33 Pages. Price $1.50.*

This specification covers materials, design, and fabrication for flanged and butt-welding-end forged and cast-steel gate and plug valves for refinery service, in sizes 1 in. through 24 in. The edition includes a single set of Pressure-Temperature Rating Tables regardless of type of flange facing, in place of the formerly used Class A and Class B rating series. There are 33 pages, including tables, and illustrations.

Fired Heaters and Stacks of the API Guide for Inspection of Refinery Equipment. *Chapter IX, First Edition. Published by American Petroleum Institute, 50 West 50th Street, New York 20, New 56 Pages. Price $2.*

This guide covers the general design of box-type, vertical, and special heaters and of smoke, flare, and blowdown stacks; reasons for inspection; causes of deterioration; frequency of inspection; safety precautions; minimum allowable thickness; method of inspecting furnace settings, stacks and other appurtenances; methods of repair and recoords and reports. There are 56 pages including tables and illustrations.

Manual on Disposal of Refinery Wastes. *Volume 3, Chemical Wastes. Published by American Petroleum Institute, 50 West 50th Street, New York 20, New York. Price $2.00.*

This manual presents recommended practices and procedures for the utilization, treatment and disposal of chemical wastes from petroleum refineries. A summary is included on the sources of chemical wastes and methods of waste control and waste treatment. The manual also contains a chapter on the recommended handling of specific refinery wastes. Tables, diagrams, and illustrations are included.

The Measurement of Thickness. *George Keinath, National Bureau of Standards Circular 585. Pages, 79. Price, 50 cents. Order from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.*

This publication surveys the available information on the various methods and problems of measuring thickness. Measurement of physical parameters involved in the practical measurement of thickness, such as displacement, is covered, in addition to some more general aspects of the measurement, such as dynamic response. The methods are treated in seven groups, according to physical operating principles; mechanical, chemical, electrical, magnetic, optical, X-ray, and radioactive radiation.

Although the methods and instruments are not described in detail, a discussion of ranges, accuracy, advantages, and limitations is included. One section discusses thickness meters for the blind. A bibliography of references, a limited list of suppliers, and a detailed index of the gages, methods, applications, and trade names covered are appended.

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Refining Personals

Frank C. Ball, who has been manager of operations for the Union Oil Company of California in the Rocky Mountains, has been named manager of the new oil shale project at Grand Valley, Colorado. **W. Layton Stanton** is now acting manager at Denver.

Three winners of the annual F. C. Zeisberg Memorial Award for excellence in report writing by students in Chemical Engineering have been announced. This award is presented by the Philadelphia-Wilmington section of the American Institute of Chemical Engineers. Winner of the first prize was **Donald J. C. Koestler,** a senior chemical engineering student at Villanova University. Second prize was won by **Donald C. Garaventi,** a senior in chemical engineering at Lehigh University. **Lester Cohen,** senior chemical engineering student at Drexel Institute of Technology, won third prize.

John J. Winterbottom, who has been transportation coordinator for Standard Oil Company (New Jersey), has been elected a vice president and director of Esso Standard Oil Company.

In his new post, he will serve as contact director for marine, supply and other activities at Esso.

Joe T. Kelly has been promoted to section head, petroleum section, research division of the research and development department of American Oil Company, Texas City, Texas. Kelly was formerly group leader in the petroleum section.

Bob L. Galloway was promoted from the superintendency of the new project development section, gasoline division, Cities Service Oil Company, to the position of assistant to the division manager. **George C. Vaughan** succeeds Galloway as head of the new project development section. Division operations have been aligned under two newly-created positions in Bartlesville, both to serve directly under **R. W. Johnston,** general superintendent. **Guy W. Duren** will direct the activities of the gasoline division's engineering and construction department, serving in the position of chief engineer. **L. T. Botts** has been advanced to the position of superintendent of plant operations.

The company's gasoline plants have been re-districted, with an assistant superintendent of plant operations in charge of each district: **D. G. Thoes** of Wichita, Kansas, for District 1, which covers operations at Hutchinson, Burrton and Wichita, Kansas, and Blackwell and Guymon, Oklahoma; **Frank M. Allen** for District 2, which covers operations at Chico, East Chico and Stonewall, Texas, and Oklahoma City, and to be headquartered at Wichita Falls, Texas; and **L. H. Davies** of Pampa, Texas, for District 3, which covers operations at Pampa, Lehman, West Seminole and Roberts Ranch near Odessa, Texas. **D. W. Bellinger** will serve under Botts in the new capacity of production engineer. Major construction projects will be coordinated by **M. F. Finfrock** and **D. F. Hogsett,** who have been named project engineers under Duren.

Willard C. Asbury, vice president of Esso Research and Engineering Company, has been named vice chairman of the advisory council of The Patent, Trademark and Copyright Foundation.

Robert R. Chase has been promoted from assistant superintendent to superintendent at The Texas Company's El Paso, Texas, refinery. **Ralph B. Erwin,** who formerly was chief process engineer at the company's Lockport, Illinois, refinery, succeeds Chase as assistant superintendent.

O. P. Puryear has been named assistant manager (industrial), technical services division of Texaco's research and technical department. Puryear succeeds **R. R. Thurston,** who retired April 1. **Louis E. Endsley Jr.** has been named to succeed Puryear as assistant manager (operations), technical services division. Endsley was formerly director of technical services of the Texas Research Center here.

Other changes at the Research Center were: **J. Stanley McKeown** succeeds Endsley as director of technical services; **Albert D. Togna** succeeds McKeown as supervisor of the field service department; **August Sellingsloh** succeeds Togna as supervisor of the products testing department; **Joseph L. Furtnett** succeeds Sellingsloh as assistant supervisor of the analytical department; and **Neil H. Fick,** formerly group leader in the products testing department, succeeds Furtnett as chemist (staff) in technical services administration.

Richard I. Galland has been named president of American Petrofina Company of Texas, operating division of American Petrofina, Inc. Galland, who will have offices in Dallas, Texas, will also serve as vice president and general counsel of American Petrofina, Inc. **J. M. Shea Jr.,** and **Frank Durham,** have been named vice presidents of American Petrofina of Texas. Other officers of the operating division are **D. R. Zachry Sr.,** executive vice president, and **Verne H. Maxwell,** vice president and general counsel.

Dr. John R. Bates has resigned as technical adviser to the executive committee of the board of directors of Sun Oil Company.

E. F. Grieb has been named assistant plant manager and **T. D. Smith,** manager of operations for the Fortier plant, organic chemicals division, American Cyanamid Company.

T. J. Hull has assumed his new duties as executive secretary, National Association of Corrosion Engineers. **R. W. Huff Jr.,** became assistant executive secretary. Hull had been assistant executive secretary for the year preceding. **A. B. Campbell,** formerly executive secretary, retired.

Victor R. Farlow has been promoted to director of petro-chemical sales, Gulf Oil Corporation. In this capacity he will direct marketing activities for Gulf's expanding petrochemical business. He was previously a sales representative in the petrochemicals department.

Dr. Fred H. Stross of Berkeley, a research supervisor in Shell Development Company's Emeryville (California) research center, has accepted chairmanship of a newly formed group in the National Research Council. Serving under Stross on the new sub-committee are **Dr. George Matsuyama** of Union Oil Company in Brea, California and **Dr. Ralph O. Clark** of Gulf Oil Company, Pittsburgh, Pennsylvania.

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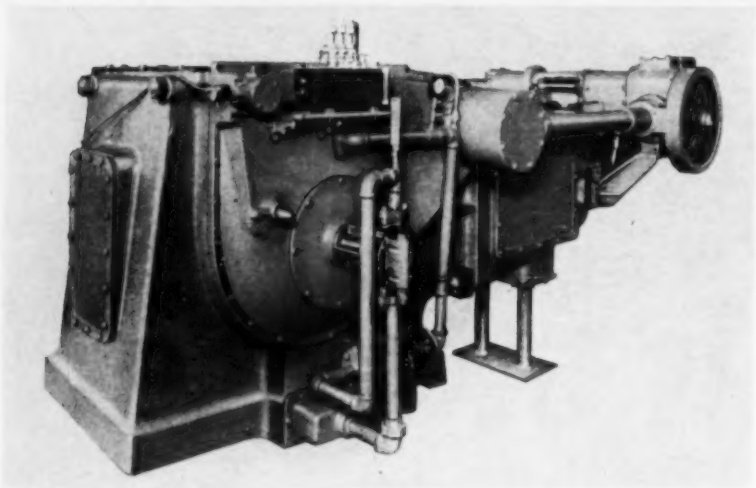


Reciprocating Expansion Engine

This new expansion engine, used in conjunction with a low temperature rectifying column, is claimed to be very efficient for liquefying or separating gases. Thermal efficiency is in the order of 75 to 85 percent and will develop temperatures as low as –300 F.

A useful application of the expander engine is in producing refrigeration for large vessels in which physical or chemical processes are being carried out at low temperatures, or simply to cool storage vessels containing liquefied gases to prevent excessive evaporation. *Cooper-Bessemer Corporation.*

Circle number (41) on reply card.

"Two-In-One" Chromatography

New dual column valve assembly adapts to former single column analyzer to make two separate instruments. With this assembly a second column may be installed either inside or outside the instrument for different uses. *Beckman/Scientific Instruments Division.*

Circle number (42) on reply card.

UPVC-Lined Fittings and Pipe

A new line of unplasticized polyvinyl chloride lined fittings and pipe will soon be on the market. Pipe, with a steel shield, and cast iron fittings are now available. Cast aluminum and steel fittings and pipe with aluminum, stainless steel or special alloy shielding will be available on special order. New line combines desirable characteristics of UPVC and metal pipe. *Tube Turns Plastics, Inc.*

Circle number (43) on reply card.

Jet Unit Tank Cleaning

A jet unit for cleaning the inside of tanks, tank cars, or tank trucks, of any size or shape is announced. Known as the Rotor Jet, unit has application to petroleum and chemical plants and other industrial installations. Operation is completely automatic, is balanced so that it can be lowered into a tank suspended by its hose, without additional support. Either a closed system (with the cleaning fluid recirculated) or an open system (with no recirculation) can be used. *Sellers Injector Corporation.*

Circle number (44) on reply card.

New Instrument Manifold

Design of a new three-way manifold connects flow transmitters. Manifold is mounted directly on orifice flanges, weighs 7½ lb. Unit contains two ½-in. stem plug valves and one ¼-in. by-pass or equalizer valve with valve seats made of replaceable Nylon or Kel-F inserts. *Anderson, Greenwood & Company.*

Circle number (45) on reply card.

New Ceramic Alumina

New ceramic material has tensile strength of 34,000 psi and retains 75 percent of this strength at 2000 F. Permanent dimensional stability, extreme hardness, resistance to wear and abrasion and very fine crystal size permitting finishing to an extremely smooth surface is claimed. *Coors Porcelain Company.*

Circle number (46) on reply card.

Anti-Corrosive Coating Steel

Cold-applied anti-corrosive coating for steel surfaces is announced. Agent is an irreversible uniform emulsion of coal-tar pitch stabilized with mineral colloids. Contains no bentonite clay, soluble soap, asphalt, sulphite pitch or sulphonic acids. Freezing has no effect on the cured film, which also does not burn, but chars at 800 F. It is non-volatile, it gives off no toxic fumes and there is no hazard during application. Can be burned through by torch or stud-welded without fear of fire. Film is claimed unaffected by most petroleum derivatives, commercial inorganic salts and acids. *Selby, Battersby and Company.*

Circle number (47) on reply card.

10,000 Psi LOX Needle Valve

New, high pressure, liquid oxygen (LOX) needle valve has been announced. Forged from 316 stainless steel for size from ⅛ to 1 in., valve operates at –300 F and up to 10,000 psi. Valve has been engineered with resiliant Teflon or Kel-F packing is used and the unit has design "burst" pressure in excess of 30,000 psi. *Dragon Engineering.*

Circle number (48) on reply card.

New Liquid Oxygen Valve

Gate valve for handling liquid oxygen has been announced; completely satisfactory service at –310 F is claimed.

Valve is so designed that the seal is on one side and on the wedge instead of the body eliminating possibility of pressure build-up within the valve due to "boiling off" of oxygen. *Hamer Valves, Inc.*

Circle number (49) on reply card.

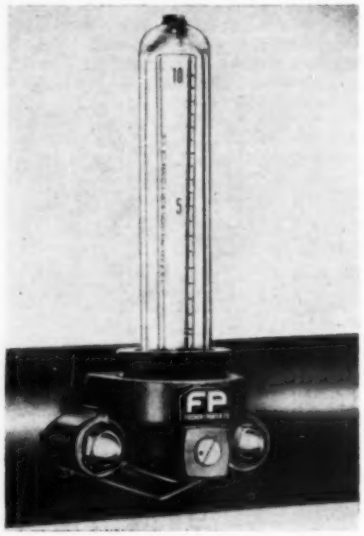
Battery-Operated Thermocouple Vacuum Gage

New single-station thermocouple vacuum gage is powered by a 1.5 v, size "D" flashlight battery. Instrument covers a range from 0 to 1000 microns Hg in one non-linear scale. Features are simple recalibration and rugged sensing tube. *Consolidated Electrodynamics Corporation.*

Circle number (50) on reply card.

New Indicating Flowmeter

This indicating flowmeter measures flow in either direction. Corrosion-resistant, requires no flanges or matching



orifice plates, the meter is quickly installed in any 1½ to 8-in. pipe. Readings are made by ball float and linear scale calibrated in gallons per minute. A number of flow ratings are available. *Fischer & Porter Company.*

Circle number (51) on reply card.

New Equipment

Mechanical Drive Turbines

High-volume flow mechanical drive turbines with 360-deg nozzle rings to permit speeds up to 12,500 rpm over a wide range of ratings without any appreciable increase in turbine dimensions are announced. It is claimed that this new design will be valuable where there is very low initial pressure, where steam must be extracted for process utilization, and where there is a short energy range requiring high exhaust pressures and/or non-condensing installations. *General Electric Company, Small Steam Turbine Department.*

Circle number (52) on reply card.

Dehydration Unit Announced

A new dehydration unit makes possible dew points of −150 F and 5-micron filtration of air, gas or liquids. Sizes range from 2 to 8 in. diam. Unit is designed for elimination of freezing and corroding in air-operated equipment such as: Intermitter valves on oil wells, control valves, gas engines, fuel gas on package process units, orifice meters, etc., also for plant air systems, process streams, etc. *Dehydrators, Inc.*

Circle number (53) on reply card.

Compact Heat Exchanger

Small rotary, air-to-air heat exchangers which can take waste gases at temperatures as high as 1000 F have been developed.

About 20 in. dia and 11 in. in overall depth, new unit can handle flows of 250 GFM. Larger units up to 4 ft dia can handle flows up to 2600 CFM. *The Air Preheater Corporation.*

Circle number (54) on reply card.

New Design in Bar Stock Valves

Veegroo tapered orifice principle has been employed in bar stock valves now being made. Valve comes in all standard sizes up to 1 in. Pressure ratings available are 3000 and 10,000 psi, with various body materials available. *General-American Valve Company.*

Circle number (55) on reply card.

Longer Life for Cation Softeners

New chemical blend, Kleen-Ion, assists in restoration of exchange capacity of cation softeners operating on sodium cycle. Materials, growths, mud and silt are dispersed or solubilized permitting removal by backwash. Product comes as dry powder and may also be used to treat siliceous or anthracite filter beds. *Betz Laboratories, Inc.*

Circle number (56) on reply card.

Chemical Conditions Crude Oil

New chemical concentrate has been developed to combat piping and heat exchanger fouling and corrosion in refinery streams. Liquid conditioner, Cronox C, is injected into desalted feed-stocks in conjunction with soda ash and water. Fouling and corrosive agents are removed without effecting processes, equipment, catalysts or products. Product is designed primarily to protect crude units. *Atlas Powder Company.*

Circle number (57) on reply card.

Dual Solenoid Inlet Valve

Dual solenoids operate a new valve that has ¾-in. inlet connections and a common 1-in. outlet. Valve is made with a heavy forged brass body and bonnet and two independently operated solenoids. Operation is on either a-c or d-c current and at most standard voltages. *Automatic Switch Company.*

Circle number (58) on reply card.

It's as if you were there . . .

If you could personally supervise each production operation from foundry . . to machining . . . to assembly, you could never be more certain of the balanced quality control you get than when you specify PACIFIC Cast Steel Valves. One reason being PACIFIC'S foundry operation is the most uniquely modern one of its kind on the west coast; equipped to assure you of the quality control so fundamental of dependable valve service. And you pay no premium for the smaller quantity run of special alloy valves at PACIFIC. Geared to meet your production wants, PACIFIC can give you faster service at a figure you will agree more than justifies the time you spent to inquire.

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New Equipment

Bellows-Type Shaft Seal

New bellows-type end-face shaft seal is announced. A Teflon sealing face the only part that contacts liquid being sealed. Bellows are integrally molded with sealing face and material may be varied for specific conditions. Seal is double-ended for internal mounting and single-faced for external mounting. *Crane Packing Company.*

Circle number (59) on reply card.

New Corrosive Fluids Pump

Designed to handle corrosive fluids, new Kemlon diaphragm-type pump is available in both simplex and duplex models. Barrier separates all working parts from fluid handled. An actuating fluid between the piston and the diaphragm does the pumping without mechanical linkage. *Keystone Engineering Company.*

Circle number (60) on reply card.

New Explosion-Proof Motors

A line of totally enclosed and explosion proof motors for industrial use has been introduced. New features include neoprene slingers on the output shaft, shock-resistant fan covers, and a foolproof lubrication system. Overside conduit boxes are standard to insure easy installation. *A. O. Smith Corporation.*

Circle number (61) on reply card.

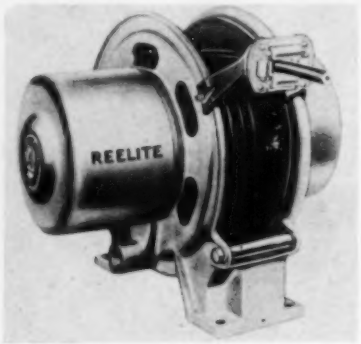
High-Speed Grease Mill

A newly designed grease mill is said to give up to 18 percent increased production time. Machine has precision drilled and hardened perforated discplates and a direct drive from motor to mill. Lower steam pressures may be used and process cycles may be changed depending on the product. *Buxton Machine & Tool Company.*

Circle number (62) on reply card.

Automatic Cable Take-Up

New single-casting-frame Reelite for industrial use has been placed on the



market. New model, the R-20, has weather-proof and explosion-proof construction. *Appleton Electric Company.*

Circle number (63) on reply card.

PVC Bleeder Valve

New bleeder valve of polyvinyl chloride has been developed for bleeding, sampling or liquid draw-off. No packing is required and closure is insured by back seat at valve stem base. PVC is nontoxic and non-corroding and offers light weight and high-burst strength. *Walworth Company.*

Circle number (64) on reply card.

New Temperature Controller

New thermocouple temperature control system is claimed to control to 0.1 F with platinum couples, or 0.025 F using base metal types. Catalog gives full details. *Boston Division, Minneapolis-Honeywell Regulator Co.*

Circle number (65) on reply card.

New Pressure Gage Line

A new line of pressure gages is now in production, meeting ASA Grade A accuracy standards. Designated the "A line," gages are said to have improvements in accuracy, style, movements, and Bourdon tubes. Built in "Mono-unit" construction, the socket, tube, tip, movement, dial, and pointer are removable in one assembly. *U. S. Gauge Division, American Machine & Metals, Inc.*

Circle number (66) on reply card.

Stress Corrosion Cracking Controlled

Stress corrosion cracking may no longer be a problem via a new alloy. A new aluminum bronze, Grade 8 alloy, is available for use in especially troublesome areas. Metal does not need stress relieving and field alterations may be made without heat treatment. *Ampco Metal, Inc.*

Circle number (67) on reply card.

Pulse Code Telemetering System

New pulse code positive displacement meter telemetering system is available for a number of applications. Readings are displayed in digital form to six places for numerical meter identification. Explosion-proof housing and easy parts servicing are prime features. *Vapor Recovery Systems Company.*

Circle number (68) on reply card.

Long-Life Thermocouple Well

Metal-ceramic thermocouple protection well for use in sulfur-burning furnaces has been announced. Up to three years life inside a 2200 F sulfur furnace is claimed. Metal-ceramic material has small temperature lag and resists shock breakage. *The Bristol Company.*

Circle number (69) on reply card.

New Refining Literature

Eight Types of Sealing Compounds Described

Bulletin shows formulations, applications, and general properties for various types of sealing and pipe joint compounds. Requirements for sealing gas, liquid lines containing hydrocarbons and other materials are detailed. *Radiator Specialty Company.*

Circle number (70) on reply card.

Proportioning Pumps Catalog

New catalog covers details and specifications of the full line of proportioning pumps offered. Maximum capacities of pumps covered range from 6cc per min to 730 gph per feed. *Hills-McCanna Co.*

Circle number (71) on reply card.

Compact Exchanger Described

A 12-page illustrated bulletin describing new Fin-Pak heat exchanger has been issued. Unit operates with low-pressure drops under high-pressure differentials for gas to gas, gas to air, or gas to air to liquids. Flow-diagrams of five applications are given: For open-cycle gas turbines, for gas cooled reactors and closed-cycle gas turbines, for diesel or gas engines, as a waste-heat boiler and in chemical processing applications. Other applications are suggested. *The Air Preheater Corporation.*

Circle number (72) on reply card.

Industrial TV Applications

New 8-page brochure illustrates line of industrial television equipment; shows different types of cameras, control units, monitors, accessories, and projection systems. Varied applications, including installations with unusual engineering requirements, are also pictured and described. *General Precision Laboratory.*

Circle number (73) on reply card.

Industrial Crane Application

New 4-page bulletin outlines applications for a self-propelled crane. Included are 12 materials handling ideas in the form of actual job reports. *Schield Bantam Company.*

Circle number (74) on reply card.

Technical Data Cards

Nominal pipe sizes, outside diameters and weights of forged steel flanges and seamless weld fittings are tabulated on Technical Data Cards FDC-251 and FDC-250. *Babcock & Wilcox, Tubular Products Division.*

Circle number (75) on reply card.

Anti-Corrosion Coating

New technical "Niphos" bulletin tells how nickel-phosphide coating is alloyed to ferrous metals for anti-corrosion, anti-erosion protection of pipe and heat transfer tubing. *Tube Reducing Corporation.*

Circle number (76) on reply card.

Steam Turbine Process Drivers

High speed mechanical drive turbines for petroleum, chemical and petrochemical industries are described in new publication GEA-6579. Drive requirements and design features for turbines to power compressors, hot oil pumps, air blowers, small generators, etc., are presented. *General Electric Company.*

Circle number (77) on reply card.

Thermal Conductivity Analyzer

Bulletin TC-4012 provides detailed information on applications, features, principle of operation and specifications of a thermal conductivity gas analyzer for measuring 1 component in a gas mixture. *Beckman/Process Instruments Division.*

Circle number (78) on reply card.

Code Selector Supervisory

Bulletin GET-2738, 20 pages, gives detailed information on the description, operation and application of supervisory control equipment. Publication describes equipment used for master and remote stations; applications for control of a-c switching stations, hydro generating stations, pumping stations, and railway conversion substations; and principles of operation of the Space Code Selector Supervisory System. *General Electric Company.*

Circle number (79) on reply card.

Compressors and Gas Turbines Catalog

New composite catalog features the complete line of standard Clark products, with latest engineering and performance data with reference to the petroleum, refining, gas, pipeline, chemical, petrochemical and other industrial applications. Sections cover reciprocating type compressors, with specifications and diagrams of the gas-engine-driven, steam-engine-driven and electric-motor-driven compressors, centrifugal compressors, with data on vertically and horizontally split multi-stage units. Pipeline, axial flow compressors and radial inflow expanders are also featured at some length. Section on gas turbines treats standard model turbines in the 1150-9300 hp range. *Clark Bros. Company.*

Circle number (30) on reply card.

Test Instrumentation Bulletin

New guide outlines indicating, recording, programming, and controlling instruments for environmental test equipment. Instruments for measuring, recording, and controlling temperature, humidity, altitude, pressure, flow, and other variables are offered. Bulletin also gives specifications for most widely used temperature-measuring systems, absolute pressure gages, pneumatic, electric, and electronic controllers, and program controllers. *The Bristol Company.*

Circle number (31) on reply card.

Analog Digital Converter

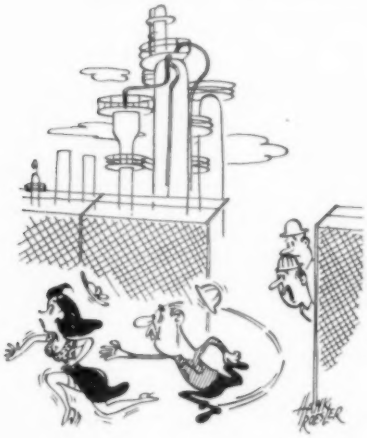
Catalog sheet describes new Digi-Coder, a device which converts a shaft position representing the analog value of a variable into a coded digital output. Output can be fed into an electric typewriter, tape punch, computer, or printer. *Fischer & Porter Company.*

Circle number (32) on reply card.

Quick-Coupling Pipe, Tubing

Illustrated Bulletin 10M-2-58 shows installation and operating features of quick-coupling lightweight pipe or tubing. Applications are also presented. *Victaulic Company of America.*

Circle number (33) on reply card.



"Old Spentpot has been fooling around that regeneration tower lately."

Planning for Profits

New booklet describes in detail engineering-construction-procurement services, and their effects on costs. Sections also cover coordination and control along with research and development. *M. W. Kellogg Company.*

Circle number (34) on reply card.

Hydrogen Booklet Published

Hydrogen production processes, types of plants, methods of purification and industrial applications are described in a new booklet, "Hydrogen." This 36-page booklet is a revised and updated second edition of an earlier publication by Girdler. *Girdler Construction Division, National Cylinder Gas Company.*

Circle number (35) on reply card.

Cleaning Air Preheaters

Reprinted article tells how regenerative air preheaters for power plants, refineries, etc., are chemically cleaned by high-pressure jetting. In-situ technique is used. *Dowell, Inc.*

Circle number (36) on reply card.

Valve Position Transmitter

New bulletin describes a pneumatic valve position transmitter for converting mechanical variables into a proportional pneumatic output pressure, which is transmitted to actuate a remote pneumatic receiver indicating continuously position of the valve or another device. Operations are illustrated with photographs and line drawings. *Builders-Providence, Inc.*

Circle number (37) on reply card.

ONLY the application-engineered

DATA GAGE*

REMOTE MEASUREMENT AND CONTROL SYSTEM

offers these exclusive advantages

NEW ACCURACY
- Only digital system with 1/16" accuracy independent of product gravity.
- Only system satisfactory for use in FLOATING ROOF TANKS.
- Only system to give reliable readings during blending turbulence.

NEW RELIABILITY
- Only system with POWER FLOAT (moving mechanical surface finder) which checks itself automatically.
- Transistors are used instead of short-lived vacuum tubes.
- A true digital system with unlimited-distance, error-safe telemetering.

NEW FLEXIBILITY
- Single dial control for both level and temperature measurement.
- 100 reading point capacity; applicable for alarm devices, valve and pump controls, remote transmission for data processing.
- Application-engineered approach gives you assured performance.

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SKINNER-SEAL COLLAR LEAK CLAMP—designed to stop every type of collar leak in oil and gas lines. Sizes: 2" to 13" inclusive.

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SOUTH BEND 21, INDIANA, U. S. A.

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The super-penetrating rust solvent

LOOSENS
rusted bolts, nuts, screws, 'frozen' parts

Liquid Wrench works *fast*... yet is absolutely safe for all metals and alloys.

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At Industrial, Automotive, Hardware, Plumbing Jobbers

RADIATOR SPECIALTY CO.
Charlotte, North Carolina

SOLDER SEAL

New Literature

Acetylene from Natural Gas

Bulletin describes the BASF process for production of acetylene by partial oxidation of natural gas feed stocks. Four pages discuss advantages of the process. Flow diagrams, schematics, are included. *Chemical Construction Corporation.*

Circle number (38) on reply card.

Heat Transfer Products

New illustrated brochure describes the men, facilities and products of company. Emphasis is placed on engineering in company's role as a heat transfer specialist. Illustrations show range of applications and engineering and fabricating facilities. *American-Standard, Ross Heat Exchanger Division.*

Circle number (39) on reply card.

Electrical Equipment Described

A new catalog, presented in a pictorial index manner, presents overall picture of the company, its facilities and principal items of electrical equipment manufactured.

Products include voltage switchgear, explosion-proof equipment, high voltage motor starters, motor control centers, and specialized products such as oilfield motor starters, cathodic protection equipment and automatic pipeline samplers. *Nelson Electric Manufacturing Company.*

Circle number (40) on reply card.

Portable O_2 Indicator

Features and performance of a portable oxygen indicator are presented in new 4-page bulletin, includes principles of operation, uses, and accessories. *Mine Safety Appliances Company.*

Circle number (110) on reply card.

Booklet on X-Ray Analysis Theory

A new 12-page booklet covers principles of operation and uses simple diagrams to illustrate the basic differences between: Film diffraction, diffractometry and spectrography. Subjects discussed include: Basic diffraction unit, Bragg's Law, Diffractometer, wide range goniometer, electronic circuit panel, counting rate computer, spectrograph assembly, scintillation, proportional and flow proportional detectors, and geiger tubes. Other pages give applications in industry and user lists. *Phillips Electronics, Inc., Instrument Division.*

Circle number (111) on reply card.

Safety Equipment Catalog

A new catalog, "Moran Safety Equipment," has been released. New catalog covers protective housings for fire fighting equipment, includes descriptive pictures, drawings, and specifications on the company's four main products: Portable fire houses, weatherproof fire extinguisher boxes, hose reel houses, and safety flash arresters. *Moran Furnace and Sheet Metal Company.*

Circle number (112) on reply card.

New Catalysts Company Described

Illustrated brochure presents information on applied catalysis and catalyst products, along with description of manufacturing facilities. Charts show major uses of many types of catalysts. *Catalysts and Chemicals, Inc.*

Circle number (113) on reply card.

New Data Book on Flexible Tubing

This 36-page booklet covers all types of flexible tubing and hose, together with the many types of couplings which can be used. It points out steps in proper application of tubing to industrial installations. *Pennsylvania Flexible Metallic Tubing Company.*

Circle number (114) on reply card.

Nuclear Liquid Level Sensor Explained

Details of a new liquid level sensor which uses radioactive material in the sensing element are available in a technical bulletin. Designed to provide an actuating signal to control or indicate a predetermined level, the unit employs beta radiation source. *Aeronautical and Instrument Division, Robertshaw-Fulton Controls Company.*

Circle number (115) on reply card.

Gas Scrubbers for Refinery-Petrochemical Uses

Line of gas scrubbers for removing and recovering waste products in the petroleum processing and allied industries, furnished in two types to handle both micron and sub-micron sized particles, are described. Scrubbers employ a simple, trouble-free principle, no moving parts. *Chemical Construction Corporation.*

Circle number (116) on reply card.

Indicating Recording-Controlling Thermometers

Catalog describes complete line of rectangular case, filled system thermometers: indicators, recorders, transmitters, and electric or pneumatic control instruments. Vapor actuated, gas actuated, and mercury actuated thermometers and thermal systems for use between limits of -125 F to 1000 F are listed and explained, along with separable wells and other accessories. *Minneapolis-Honeywell Regulator Company, Industrial Division.*

Circle number (117) on reply card.

Indicating Flowmeters Bulletin

New line of indicating flowmeters is described. Included are ranges, scales, pressures, and mechanical details of the complete line of flowmeters designed for use with air, gas, and liquids. *Seico Instrument Division, Eclipse Fuel Engineering Company.*

Circle number (118) on reply card.

Flowmeter Selection

Technical bulletin, "How to Select Flowmeters," gives criteria for choosing the type of flowmeter to be used in measuring a given fluid or liquid. Advantages and limitations of basic types are listed in chart form. Major manufacturers of various types are also given. *Fischer & Porter Company.*

Circle number (119) on reply card.

O_2 Analyzer for FCCU

Bulletin describing the use of an oxygen analyzer on a catalytic cracker of a major oil refinery is now available. Illustrations and a flow diagram presents details on the analyzer which has been in continuous operation since October 1954. *Beckman/Process Instruments Division.*

Circle number (120) on reply card.

Speed Trench Cleanout, Backfilling with a 22-B

Bucyrus-Erie 22-Bs are available with tractor-type crawlers for extra clearance over rock, stumps, and other obstructions normally encountered. The machine shown here cleans a ditch for a gas line south of West Bend, Wis. On this job it excavates through sand, clay, rock, and muck. Four other 22-Bs are working on this contract for a satisfied owner.

Pipeline contractors the country over are switching to Bucyrus-Erie 22-Bs because these machines offer the dependable performance that keeps jobs moving despite tough going. Available with standard or tractor-type crawlers, Bucyrus-Eries defy rough terrain . . . keep going without excessive downtime. You, too, can benefit from the money-making features of a Bucyrus-Erie 22-B. Look over the jobs pictured. Compare the conditions with those on your own spread. Then see your nearby Bucyrus-Erie distributor for the full story on the 22-B. Ask for the Bucyrus-Erie pipeline construction bulletin, SE-PL-1 or write us direct. Bucyrus-Erie Company, South Milwaukee, Wisconsin.

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BUCYRUS ERIE

A Familiar Sign at Scenes of Progress

BUCYRUS-ERIE COMPANY • SOUTH MILWAUKEE, WISCONSIN

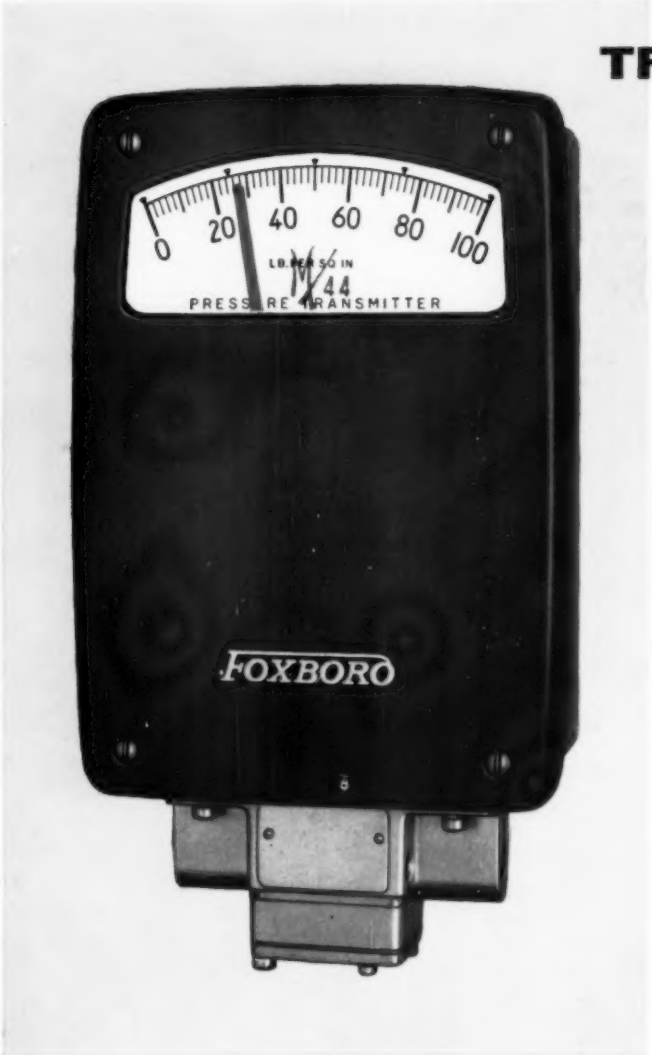
This 22-B trenches at the bottom of a hill for a gas line in Alabama. Tractor-type treads on this machine have deep grousers for sure traction in soft ground and for climbing steep grades. Special sealing helps protect tractor-roller bearings against damage from water, dust, dirt, and grime.

The 22-B shown here teamed up with a 15-B to excavate for a natural gas pipeline in New Hampshire. It was used for making river crossings and backfilling difficult swamps. At one time it backfilled a ditch on an extreme bank where no other machine could be used. Their owner reports he could not have gotten the job done without the Bucyrus-Erie machines.

In Louisiana this 22-B cleans out trench prior to laying a 30-in. gas pipeline. The controls of this machine speed the work . . . provide accurate regulation of all functions. Operating smoothness adds to operator efficiency, and quality construction contributes long life.

read pressure up to 20 ft. away!

on the FOXBORO M/44 INDICATING PRESSURE TRANSMITTER



You can check pressure readings at a glance on the Foxboro Pneumatic Indicating Pressure Transmitter. Its open-face, horizontal, 4-inch indicator scale and eye-catching red pointer are clearly visible as far away as 20 feet.

But high readability is just part of the story. Actually, this instrument was engineered from the ground up. Makeshift arrangements have been eliminated, hung-on gauges are gone. Everything is included in one compact (5¾" x 8⅛"), ready-to-install instrument that weighs only eight pounds.

Because the indicating pointer is direct-connected to element and transmitter, calibration is easy . . . and you can re-zero the transmitter externally. All M/44 components are standard, performance-proved Foxboro parts. This makes it easier to stock and service.

A wide selection of interchangeable Foxboro pressure measuring elements gives the M/44 range limits of 0-30" water to 0-6000 psi. Elevated ranges are available, too.

Write for complete details. **The Foxboro Company, 386 Norfolk Street, Foxboro, Mass.**

FOXBORO REG. U.S. PAT. OFF. **INSTRUMENTATION FOR INDUSTRY**

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

We're Guided By Service As Well As Performance

IN STANDARDIZING ON GASO PUMPS

Let's face it. It isn't pumps but *pumping service* that we buy when we place a pump order; and it's service that sold us on Gaso Pumps. Service that starts with intelligent recommendations by nearby distributors. Service that continues through years of dependable performance. And service that extends, in many cases, a quarter-century beyond the purchase date, with the immediate delivery of parts for long-obsolete standard models. Because of such service, Gaso became a habit with us...a habit we made official by specifying Gaso Pumps whenever the requirements fall within their capacity range.

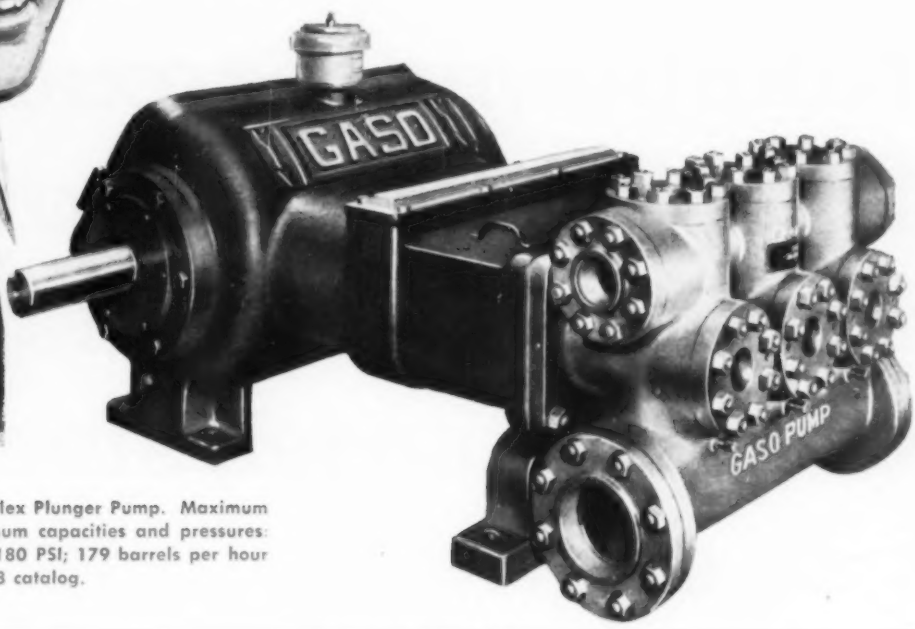


Fig. 3466 Horizontal Triplex Plunger Pump. Maximum speed, 250 RPM. Maximum capacities and pressures: 91 barrels per hour at 1180 PSI; 179 barrels per hour at 600 PSI. Write for 1958 catalog.

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Export Office: 149 BROADWAY, NEW YORK

GASO PUMPS

for every oil industry need

A pipeline pumping station—powered by a gas turbine and equipped with a heat exchanger—has a decided economic edge over other stations. Manpower, for example, is as little as 20% of that needed by stations powered by diesel, steam or gas engines.

What part does the heat exchanger play? If it's an APCO extended sur-

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face regenerator, it can recover up to 80% of the available heat in the gas turbine exhaust . . . and thereby cut fuel by 30%.* What's more, it takes less than 500 manhours to erect a unit on a 5000 hp cycle. Maintenance needed thereafter: zero For details, contact:

Air Preheater Corp.,
60 E. 42nd St.,
New York, N. Y.

*At 1500 F, a 6-1 pressure ratio, and a designed effectiveness of 75%.

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PIPELINE DEVELOPMENTS ★ ★ ★

Roundup of Planned and Proposed Construction

The following tables list the company, mileage, pipe size, and location of proposed pipeline projects — crude, products, and natural gas — reported to *The Pipeline Engineer*. Company addresses are given when known.

CRUDE LINES

Name of Company	Miles	Size	Location
Act Oils Toronto, Ontario, Canada	350		Line from Peace River area in British Columbia, thru Pine Pass to Prince George, westward to Bella Coola terminus on Pacific Coast
Afrique du Nord Development Societe	850	18	Hassi-Messaoud field, Algeria, to Mediterranean port
Alaska Yukon Pipe Lines, Inc.	254	—	Valdez to Tok Junction, Alaska
Alborz Oil Company	1000	38	Qum, Iran, to Alexandretta, Turkey
Argentine Government (YPF) Buenos Aires, Argentina	640	12	Campo Duran fields to Rosario
Atlantic-Cities-Service-Continental-Gulf-Phillips-Texas-Sinclair	Approx. 385	26	Midland, Texas, area to Houston
Bituminous Oil Pipeline, Ltd. Calgary, Alberta, Canada	250	—	McMurray to Edmonton, Canada
Bolivian Government (YPFB) La Paz, Bolivia	215	8, 10	Interior of Bolivia to Arica, Chile
Cape Pipe Line Company Philadelphia, Pennsylvania	200		Large diameter from Delaware Bay to Greater Philadelphia area refineries
Creole Petroleum Corp. Caracas, Venezuela	86	30	Temblador field to Caripito, Venezuela
Gillette Pipeline, Inc., and A. W. Hartwig, Inc.	102	—	Dead Horse Creek field to Casper, Wyoming
Great Northern Railway Co. St. Paul, Minnesota	600	12–20	Williston Basin to St. Paul-Duluth-Superior, Wisconsin-Minnesota area
Iraq Petroleum Co. London, England	Approx. 600		Kirkuk field to Iskenderun, Turkey
Jayhawk Pipe Line Corporation Wichita, Kansas	242	10, 12	Meade County, Kansas, to Valley Center
North-West Oil Pipelines Company	210		Wilhelmshaven, on the North Sea, to industrial Ruhr area of West Germany
Offshore Gathering Company Houston, Texas	364	20	Gulf of Mexico from Sabine Pass to Mississippi River
Oil Field Pipe Line, Inc. and Panhandle Eastern Pipe Line Co. Kansas City, Missouri	200	8, 12	Elkhart to Ellinwood, Kansas
Royal Dutch Shell Group and Others The Hague, Netherlands	870	30	Marseille, France, to Rotterdam, Holland, and Antwerp, Belgium
Royal Pipe Lines, Ltd. Regina, Saskatchewan, Canada	288	Var.	Cantuar area fields to Glenavon
Shell Pipe Line Corporation Houston, Texas	100		Southwest Pass Terminal to Norco, Louisiana, refinery
Southern Kansas Pipe Line Company Arkansas City, Kansas	310	6, 10	Greenwood pool, near Colorado line, thru Liberal to Arkansas City, Kansas
Trans-Border Line Company	110		Skagway, Alaska, to Whitehorse, Yukon Territory
17 American, English, French and Dutch Companies	1500	38–40	Middle East producing areas to Mediterranean Coast in Turkey
Yacimientos Petroliferos Fiscales Buenos Aires, Argentina	375-434		Challaco, Neuquen Province, to Arroyo Parejas

PRODUCT LINES

Name of Company	Miles	Size	Location
American Pipe Line Co. New York, New York	1910	8–26	Beaumont, Texas, to Newark, New Jersey
Buckeye Pipe Line Company, New York, New York	50	10	Syracuse, New York, to shipper terminals at Utica
Conn-Mass Pipe Line, Inc.	328	6, 8, 16	In Connecticut, Massachusetts, New Jersey
Hydrocarbons Pipelines, Ltd. Winnipeg, Manitoba, Canada	800	6–8	Edmonton, Alberta, to Fort William, Ontario
M.K.&T. and New York Central Railroads	2000	—	Houston-Kansas City-St. Louis-Indianapolis-Cleveland-Syracuse, New York, with branches to Chicago and Detroit
Mene Grande Oil Company Caracas, Venezuela	60	6	Anaco to Puerto La Cruz, Venezuela
Northwest Pipeline Corporation Salt Lake City, Utah	350	8–10	Four Corners to Salt Lake City, Utah
Service-Continental-Sinclair-Phillips	550		Salt Lake City, Utah, to Spokane, Washington
Underground Storage and Exploration, Inc. Upper Darby, Pennsylvania	393	6, 8, 12	Moundsville, West Virginia, to Newark, New Jersey, with laterals to Mauch Chunk, Marcus Hook, and Philadelphia
Union Oil Company of California Los Angeles, California	815		Shale oil plant, Rifle, Colorado, to Los Angeles area
Winnipeg & Central Gas Company Winnipeg, Manitoba, Canada	210	6	U.S. Canadian border to Winnipeg

GAS LINES

Name of Company	Miles	Size	Location
Andes Pipeline Corporation	500	12	Villamontes, Bolivia, to Antofogasta, Chile
Argentine Government (YPF) Buenos Aires, Argentina	815		Campo Duran fields to Buenos Aires
Arkansas Louisiana Gas Company Shreveport, Louisiana	300		Main and gathering lines Louisiana-Texas Gulf Coast
Coastal Transmission Corporation	574	22–26	McAllen, Texas, to Baton Rouge, Louisiana
Dallas, Texas	414	Var.	Gathering lines in Rio Grande Valley, Texas
Colorado Interstate Gas Company Colorado Springs, Colorado	917	4–34	New lines, loops, replacements in Texas, Colorado, Nebraska, New Mexico, Kansas, Oklahoma
Cuban Gas Transmission Company (Edwin Pauley) Los Angeles, California	1000		Mexico to Florida via Cuba
Eastern Shore Natural Gas Company Salisbury, Maryland	124	6, 8	Transmission line and facilities in Delaware and Maryland
Edison Securities Company Los Angeles, California	130		San Joaquin Valley to Los Angeles
El Paso Natural Gas Company El Paso, Texas	533	6–30	New lines and loops, New Mexico, Arizona, and Texas
	216		Main line additions in Arizona, Texas, and New Mexico
	533		Field lines in New Mexico and Texas
Houston Texas Gas & Oil Company Houston, Texas	942.6	12–30	Baton Rouge, Louisiana, to Miami, Florida Laterals to serve Florida distributors and industrial users
Iron Ranges Natural Gas Co.	120	6, 12	Mesabi Iron Range to northern Minnesota
	63	12	North Shore of Lake Superior
Kentucky Gas Transmission Corporation Charleston, West Virginia	20.5	26	To parallel existing lines in Bracken County, Kentucky
Michigan Wisconsin Pipe Line Company Detroit, Michigan	638	4–24	Laterals and loops in Wisconsin, Michigan, Missouri, Illinois, Indiana
Midwestern Gas Transmission Company Houston, Texas	2067	3–24	Main line from U.S.-Canadian border near Emerson, Manitoba—Noyes, Minnesota, to Portland, Tennessee Laterals off main line to serve communities in Minnesota, North Dakota, and Wisconsin
Natural Gas Pipeline Company of America	416	36	Loop from Beatrice, Nebraska, to Joliet, Illinois
Chicago, Illinois	337	30	Loop from Fritch, Texas, to Beatrice, Nebraska
Niagara Mohawk Power Corp. Syracuse, New York	196	2–16	Central, eastern, and northern New York
North Carolina Natural Gas Corp. Fayetteville, North Carolina	625	2–16	Intrastate line in North Carolina
Northern Natural Gas Company Omaha, Nebraska	1355	2–30	New lines and loops, Minnesota, Wisconsin, Alberta, Texas, Oklahoma, Kansas, Nebraska, Iowa
Northern Plains Natural Gas Company (subsidiary of Northern Natural Gas Company) Omaha, Nebraska	1100	26	Alberta-Montana border to Minneapolis, Minnesota
Oklahoma-Missouri Gas Transmission Company, Tulsa, Oklahoma	500	24	New system extending from Bradley, Oklahoma, district to Rolla and Webster Groves, Missouri
Pacific Gas & Electric Company San Francisco, California	1300	36	Alberta, Canada, gas fields to Antioch, California
Petroleos Mexicanos Mexico City, Mexico	130	22	Reynosa to Monterrey
Piedmont Gas Co. Hickory, North Carolina	78	2–8	In Gaston, Lincoln, Catawba, Caldwell, and Burke counties, N. Carolina
Southern California Gas Co. **Southern Counties Gas Co.** Los Angeles, California	83	34	From Coles Levee to Newhall
Southern Natural Gas Company	144	20, 24, 26	South Louisiana loops
Birmingham, Alabama	215	Var.	Supply lines Southern Louisiana.
Tennessee Gas Transmission Company	556	30	South of New Orleans to Portland, Tennessee
Houston, Texas	76	24	Coudersport, Pennsylvania, to Hamburg, New York
	163	30	Loop from Portland, Tennessee, and Winchester, Kentucky, to Lancaster and Morehead, Kentucky
	39	26	Loop from Catlettsburg, Kentucky, to Broad Run, West Virginia
	12	26	Loop south of Mercer, Pennsylvania
	50	26	Loop from Morehead, Kentucky, to Catlettsburg, Kentucky
	350		Portland, Tennessee, to Joliet, Illinois
Tensas Gas Gathering Corporation, Shreveport, Louisiana	37	2–8	Rodney field, Mississippi, to Olin Gas line connection across Mississippi River in Tensas Parish, Louisiana
Texas Eastern Penn-Jersey Corporation Shreveport, Louisiana	65	30	Loop from Delmont, Pennsylvania, to Lambertville, New Jersey
Trans-Canada Pipe Lines, Ltd.	492	30	New line from Kapuskasing, Ontario, to Sheridan, Ontario, Canada
Calgary, Alberta, Canada	48	24	New line from Winnipeg, Manitoba, to Emerson, Manitoba, Canada
Transcontinental Gas Pipe Line Corporation Houston, Texas	375	3–36	Main line loops, laterals, extensions to system
Transwestern Pipeline Company,	670	30	Mainline from Roswell, New Mexico, to Topock, Arizona
Houston, Texas	635	24	Two laterals from West Texas and from Texas-Oklahoma Panhandle gas fields converging at Roswell
United Gas Pipe Line Company Shreveport, Louisiana	202	30	Loops from southeast Louisiana to Mobile, Alabama

Look into PARSONS® Trenchliners® for pipeliners

For opening any size trench — from largest cross-country transmission lines to small feeder lines, laterals, gathering systems, there's a size Parsons Trenchliner to fit your exact requirement. With 10 different models to choose from, big Parsons line offers: *5 wheel-type* Trenchliners digging 12 to 52 inches wide, at depths to 8½ feet — *5 ladder-type* Parsons Trenchliners digging 6 to 72 inches wide, at depths to 19 feet.

Small-wheel 130

Here's a good, small wheel-type Trenchliner, in the popular low-price range, that digs up to 18 lineal feet of trench per minute, 12 to 24 inches wide at depths to 5¾ feet. Hydraulic power raises and lowers the wheel on vertical mast with fractional-inch accuracy — and tilts the mast for traveling or trailer-loading. A shiftable, reversible belt conveyor gives controlled discharge (hydraulic conveyor drive optional). This low-cost 130 also has cast-steel buckets with self-sharpening, reversible "Tap-In" teeth, quick-change gumbo buckets, retractable bucket-cleaner, etc. It's heavy-duty, high-quality in every detail.

Look at the work range of this medium-size 170 Trenchliner, with its extra-wide wheel-frame. You get trench widths from 20 to 32 inches — depths to 5¾ feet — digging speeds up to 25 lineal feet per minute. Hydraulic control on conveyor gives belt speeds up to 600 feet per minute — *completely independent of digging wheel speeds.* Belt easily handles maximum yardages from the extra-wide wheel. Want more facts? See Parsons distributor — or send coupon.

Wide-wheel 170

Mail to: **PARSONS COMPANY, Newton, Iowa**

Send us literature on: ☐ 130 ☐ 170 *Trenchliner*

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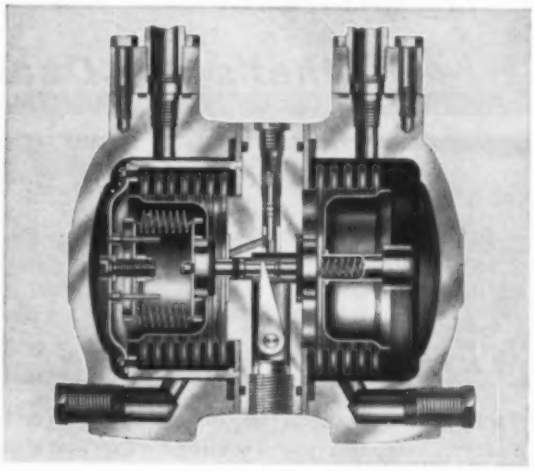
NEW!

Honeywell Bellows Meter...

unequalled for accuracy, stability, versatility in flow and liquid level metering

The new Honeywell Bellows Flow Meter gives the better performance demanded by its potential users. It's the most advanced meter body available today, with important advantages never before found in flow and liquid level meters.



Some of its outstanding features:

Sensitive and accurate—Sensitive to within 0.05% of full scale ... calibrated accuracy ±0.5% of full scale.

Leakproof—Between liquid fill and process fluid.

Automatically stabilized—Changes in meter body temperature or static pressure have no effect on output shaft position. The Honeywell Bellows Meter operates efficiently in surrounding temperatures of minus 40°F to plus 250°F.

Unmatched convenience features—Including fast range changing in the field ... connections for both horizontal and vertical piping ... quick calibration and adjustment ... easy cleaning and servicing.

High corrosion resistance—Seamless, stainless steel formed bellows give long, trouble-free service with virtually all process fluids.

Fast, effective damping adjustment—New type pulsation check with rectangular orifice enables essentially linear damping adjustment ... and you can adjust from outside the meter body during operation.

Models are available in many ranges, for both flow and liquid level measurement and control. Get details on *all* the features of the new Honeywell Bellows Meter by calling your nearby Honeywell field engineer today ... he's as near as your phone.

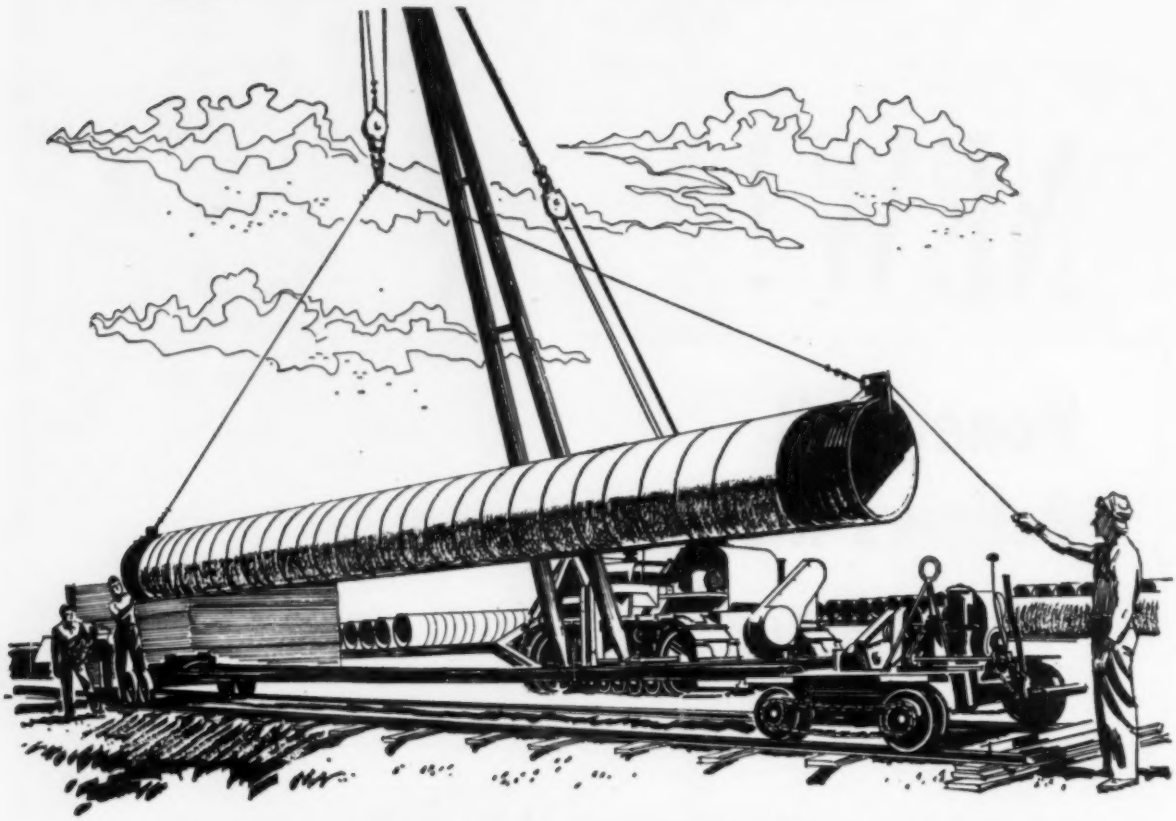
MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

REFERENCE DATA: Catalog C22-1

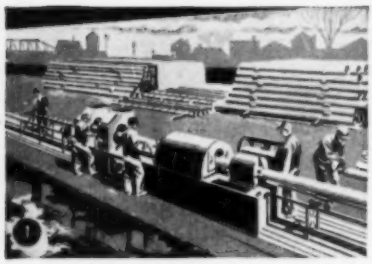
Honeywell

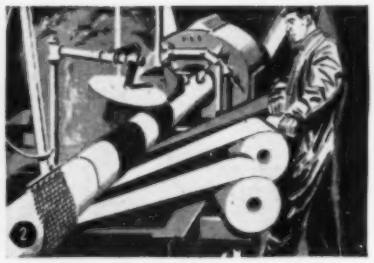
First in Controls

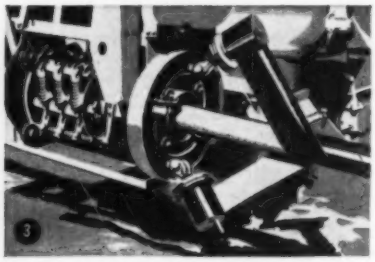
no one coating is best for every job



that's why Dearborn supplies all three







Varying circumstances, job conditions, and even budget limitations prohibit specifying one type of coating for every pipeline. That's why Dearborn offers you all three: asphalt coatings; wax-type coatings; polyethylene plastic tape. These superior coatings, together with the correct primers and wrappers, may be applied at the mill, railhead, by hand or Traveliner. Your local Dearborn representative can help you select the right coating combination for your specific job at lowest possible cost.

CALL YOUR DEARBORN MAN OR WRITE FOR INFORMATION

1. Asphalt Coatings. Write for your copy of Bulletin 3083-A.
2. Wax-Type Coatings. Write for your copy of Bulletin 3050.
3. F.O.S. SAFE-T-CLAD Polyethylene Plastic Tape. Write for Bulletin 3002.

Dearborn® CHEMICAL COMPANY

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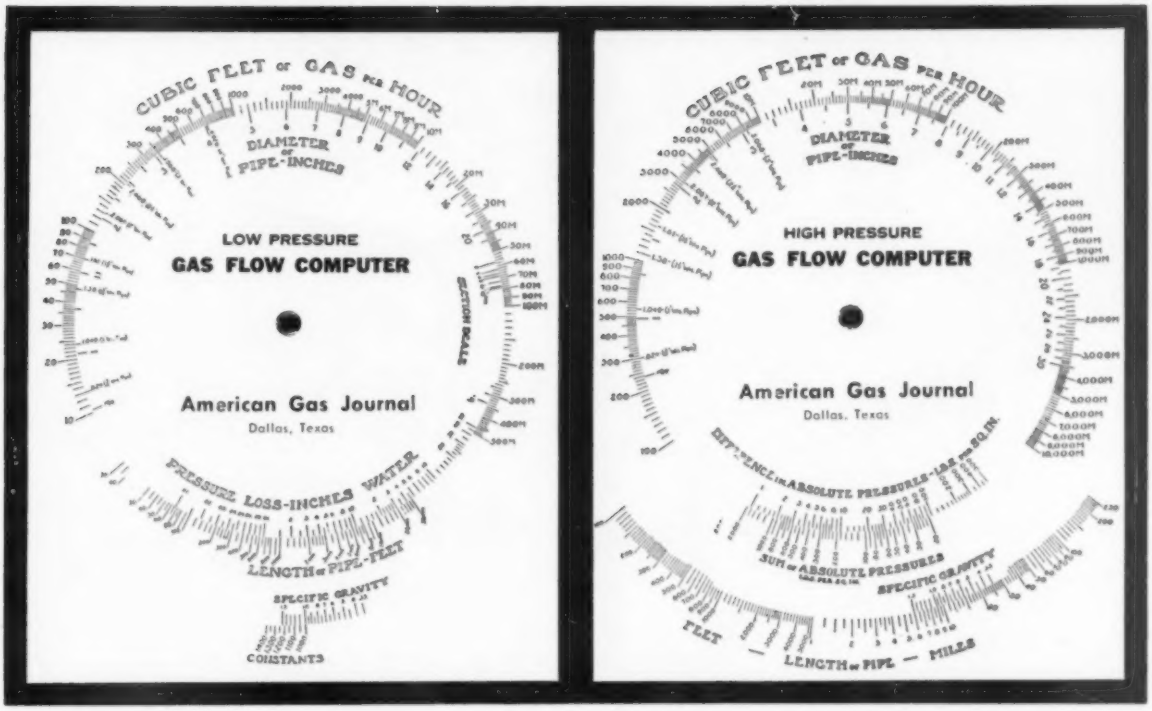
Speed up your calculations on pipe sizing, pressure drop, flow with the American Gas Journal . . .

GAS FLOW COMPUTERS



For LOW Pressures

Cubic feet of gas per hour	*10 to 500M*
Pipe diameters	*¾-in. to 48-in.*
Pressure loss (inches)	*.01 to 50*
Specific gravities	*.35 to 1.5*
Constants	*1000 to 1400*
Pipe length (feet)	*30 to 30,000*

For HIGH Pressures

Cubic feet of gas per hour	*100 to 10,000M*
Pipe diameters	*¾-in. to 30-in.*
Difference in absolute pressure to	*500 psi.*
Sum of absolute pressures	*20 to 2,000 psi.*
Specific gravities	*.35 to 1.5*
Pipe length (feet)	*100 to 5,000*
Pipe lengths (miles)	*1 to 250*

The computers are printed on heavy durable plastic, enclosed in Fabrikoid cases with complete instructions for their use.

PRICE: $7.50 EACH

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1. Complete Quality Control
As a basic producer, Pittsburgh maintains rigid quality control standards at every step of enamel production, from coal to finished coating.
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Published to guarantee you consistently superior quality and performance from every drum of *Pitt Chem* Pipeline Enamels—in application and in service.
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Pitt Chem sales representatives are experienced coating men. They talk your language, will help you plan the many requirements of your coating job.
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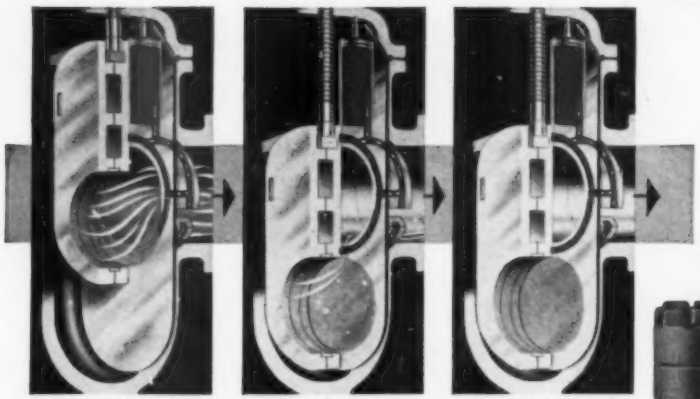
For pipeliners who hate leaks!

DARLING-McEVOY SELF-SEALING CONDUIT VALVES



APPROACHING CLOSURE ... *No loss of sealant as sealing groove in seat is disconnected from reservoir until gate is fully closed.*

CLOSED ... *Jumper in gate now permits differential pressure to feed sealant into seat groove to check any remaining flow.*

AUTOMATICALLY SEALED ... *Pressures again in balance. Tightness established. No additional sealant used until again needed.*

THE DIAGRAMS above show how these unique conduit gate valves seal themselves *automatically* . . . by means of a long lasting reservoir-held sealing compound . . . for leak-proof, pressure-tight closure every time! This feature, with flow in either direction, self-aligning non-wedging gates, and fully protected non-distorting seats, means exceptional performance, utility and service life. For additional information on these fully field-proved Darling-McEvoy valves, ask for Bulletin 5402.

DARLING VALVES

DARLING VALVE & MANUFACTURING CO.

Williamsport 2, Pa.

Manufactured in Canada by Sandilands Valve Manufacturing Company, Ltd., Galt 19, Ontario

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Stop damage to enamels from earth loads and soil movement....

Johns-Manville Asbestos Wraps are available in 3 types for field application or mill wrapping.

Soil stress tests show the effective shielding action of J-M Asbestos Wraps. 18" coated sections of 4" O.D. pipe were buried in bentonite clay which was first wetted down and then allowed to dry out. At the end of 28 wetting-drying cycles, J-M Asbestos Wraps were found to give excellent protection to the enamel.

Plasticized enamel without J-M Asbestos Wrap ←

→ **Plasticized enamel after protection with J-M Asbestos Wrap**

Get lasting protection with tough, strong J-M Asbestos Wraps

Extensive research and field tests conducted by a leading firm of consulting engineers have demonstrated the effects of soil movement and earth loads on pipeline enamels. They show how the forces of the soil tend to distort and induce thin spots that weaken the protective coating . . . permit corrosion of the pipeline.

The same research and field tests also demonstrated that J-M Asbestos Wraps provide the strong protection that strong coatings need and deserve. "Asbestos Wraps offer the most effective single protection against damage —prolong the working life of pipeline enamels." Here's why . . .

Asbestos is an ageless mineral. Fibers of asbestos are strong and tough . . . cannot rot or decay. As used in J-M Wraps, the fibers are felted, then impregnated with a coal tar or asphalt saturant to form literally a flexible covering of stone. These "stone-like" qualities form a durable shield—protect pipeline enamels from earth loads and soil movement which weaken coatings and permit pipe corrosion to set in.

Pipeline engineers are invited to write for their own copy of PP-34A, a *3-Point Study of Pipeline Coatings and Wrappers*, at no cost or obligation.

Johns-Manville, Box 14, New York 16, N. Y.
In Canada, Port Credit, Ontario

JOHNS-MANVILLE

JOHNS MANVILLE JM PRODUCTS

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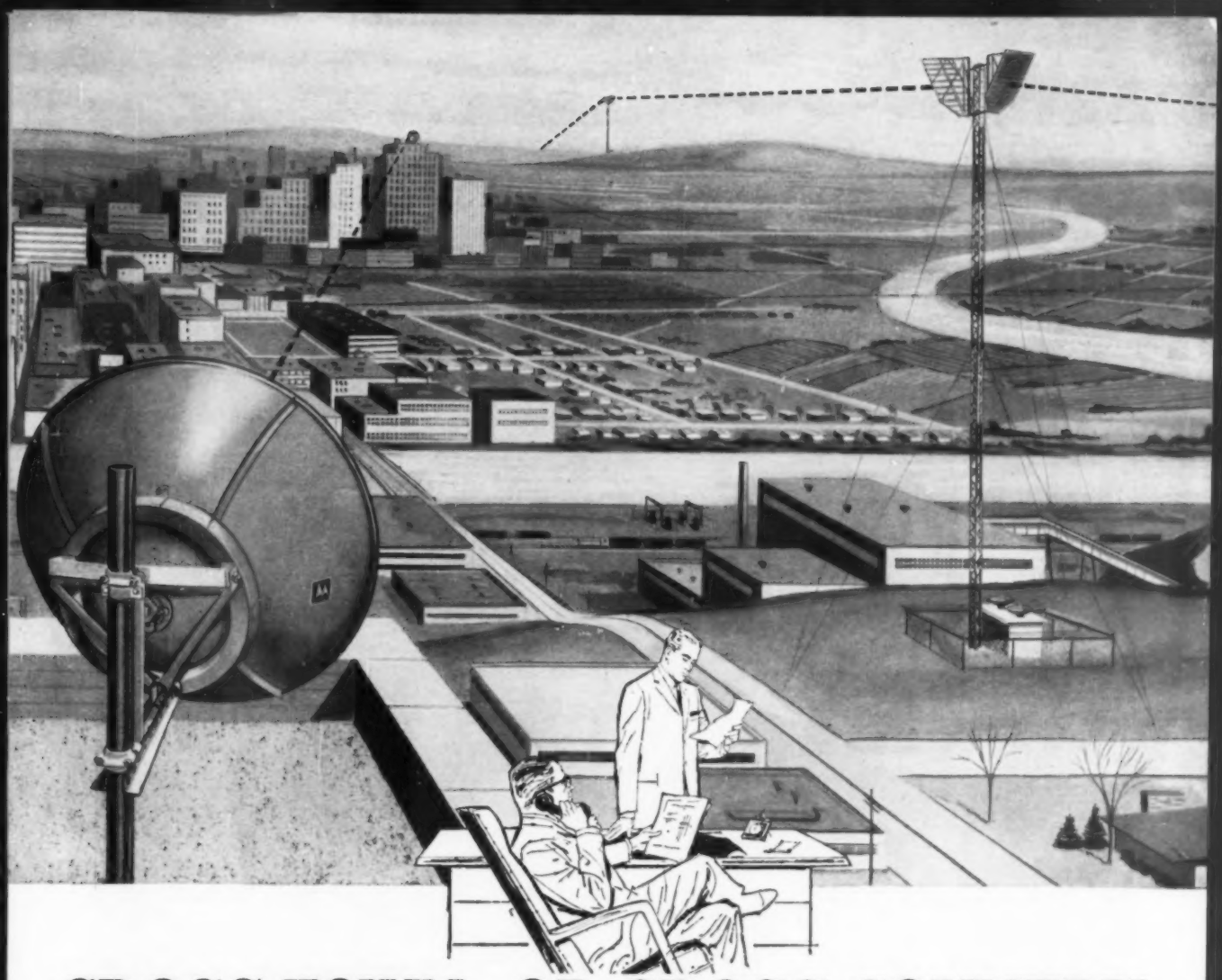

CROSS-TOWN...OR CROSS-COUNTRY

Your Motorola Microwave System puts complete, low cost operational control at your fingertips

Here is a communications medium that will return its cost many times over in increased efficiency. This single system will handle all of your control, voice, printed messages and 2-way radio signals.

Motorola Microwave works around-the-clock, fair weather and foul, to speed a thousand tasks a day . . . spanning city streets, rivers and mountains with ease. You get better control, improved coordination and increased efficiency throughout your organization. And with Motorola, you get the benefits of years of experience in serving all types of applications.

Motorola's reputation for dependability with less maintenance is your assurance that you can't buy a better system. Let our representative show you operational records that prove Motorola Microwave performs better, lasts longer and costs less to maintain . . . or write for Microwave Bulletin today.

VOICE
Private line and party line—VHF mobile and base station 2-way radio . . . all can be carried hundreds of miles, economically and privately, by Motorola Microwave.

PRINTED MESSAGES
Read a message, a chart or facsimile a thousand miles away . . . assemble information quickly. Teleprinting, telemetering, telegraph and facsimile are at your command.

CONTROL SIGNALS
Read meters, turn valves, gather and process data from any central location. With Motorola Microwave you can have supervisory and remote control.

MOTOROLA MICROWAVE

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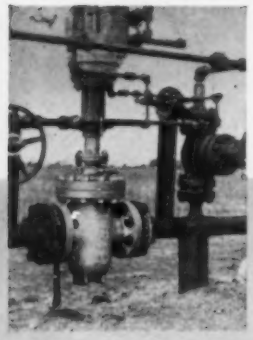
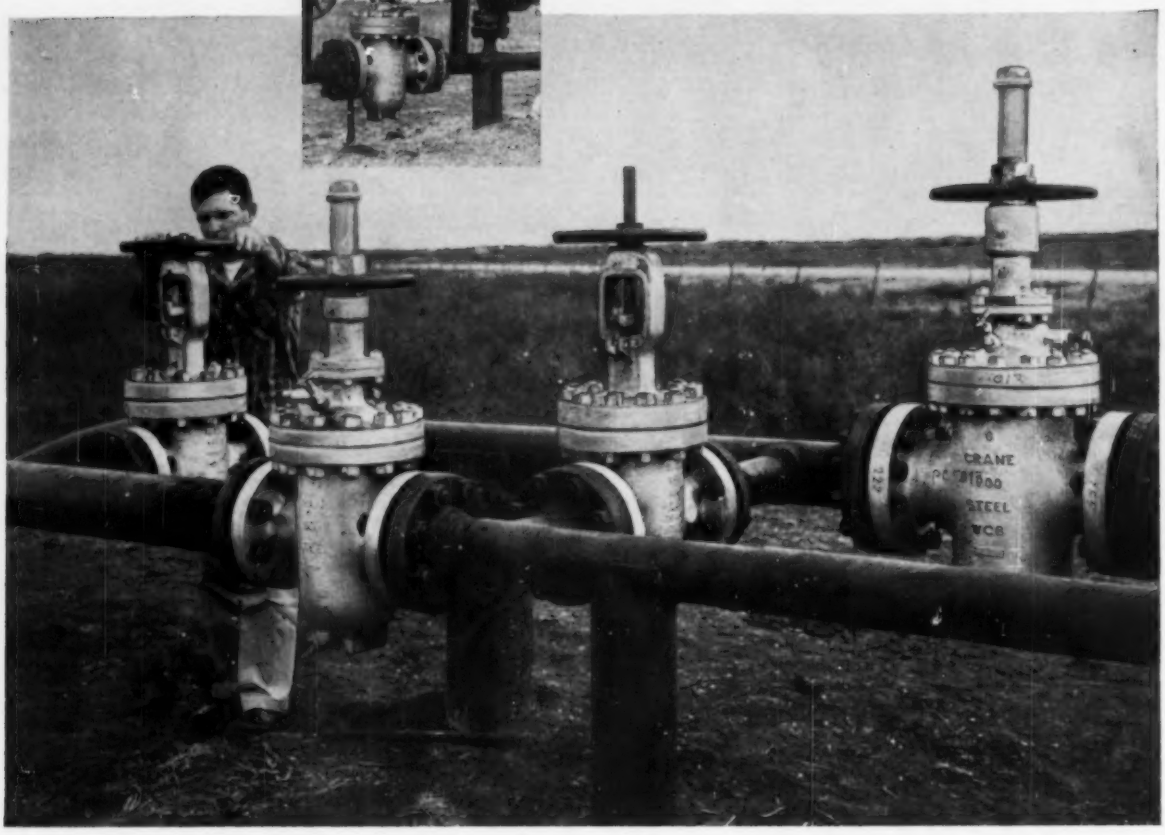


Left—Crane conduit-type valve with automatic operator at one of six stations.

Below—4- and 6-inch Crane conduit-type valves at scraper trap setting in 70-mile ethylene line.



Ethylene Handled by Crane Conduit Valves in Phillips Chemical's 70-Mile Line

Phillips Chemical Company's ethylene pipeline from the Sweeny refinery to its Pasadena, Texas, plant crosses some 70 miles of rough, jungle-like country.

Valving for the line had to be specially designed to protect against product loss, and to insure safety.

All the line valves are new-type Crane conduit gates, Class 600 and Class 900. At six locations they are equipped with automatic operators. Should line leakage cause a pressure drop of 30 to 40 pounds, these valves will close automatically in 22 seconds. Other conduit valves are installed in the scraper trap settings.

Since they were installed a year and a half ago, these valves have operated without trouble of any kind. They close tightly and easily, and require no maintenance or periodic lubrication.

Both the *new* Crane conduit valves and the companion line of Crane double-disc pipeline valves are described in Crane Catalog AD-2198. A request to the address below or a call to your local Crane outlet will bring a copy quickly.

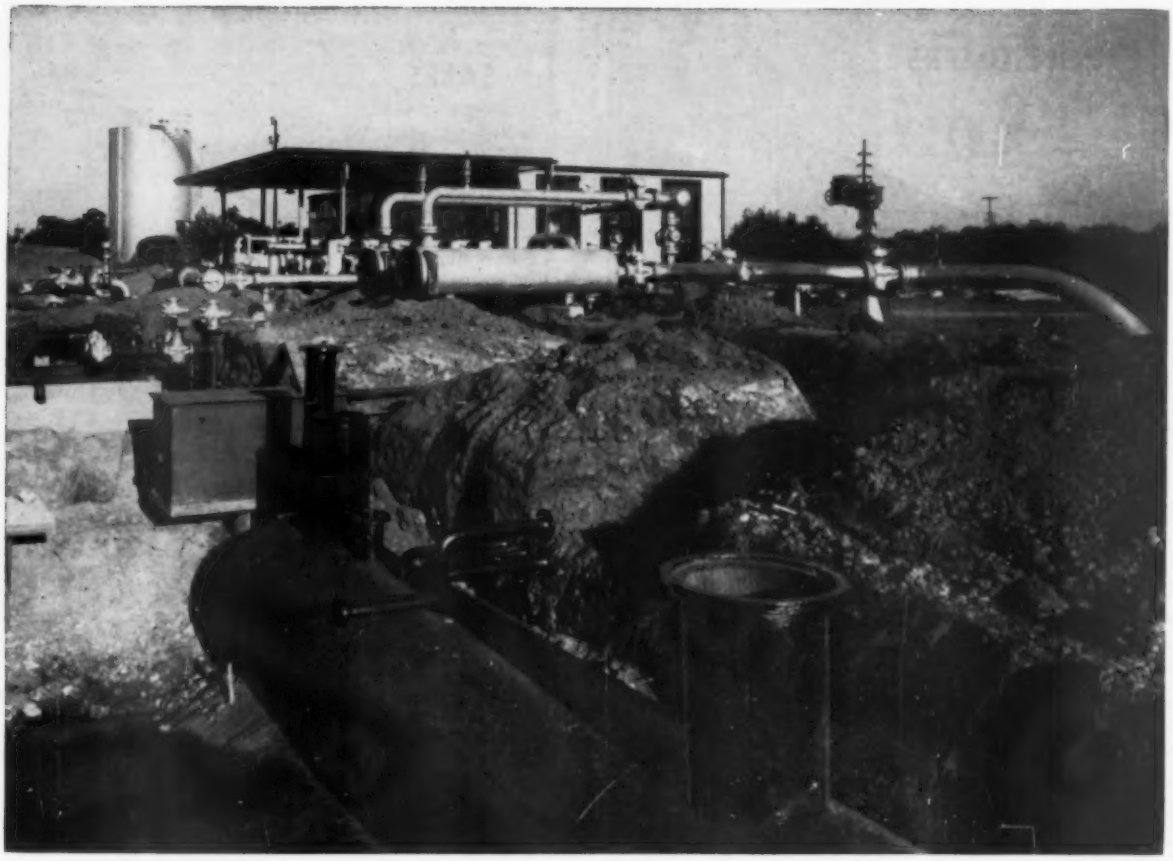
ASK FOR CATALOG AD-2198—Completely covers the new companion lines of Crane conduit-type and double-disc pipeline valves.

CRANE VALVES & FITTINGS

PIPE • PLUMBING • KITCHENS • HEATING • AIR CONDITIONING

Since 1855—Crane Co., General Offices: Chicago 5, Ill.—Branches and Wholesalers Serving All Areas

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



Considerable underground station piping, sump tanks, and main line valve and scraper trap risers, along Plantation Pipe Line Company's new 18-inch line from Baton Rouge, Louisiana, to Helena, Alabama, were coated with Roskote A-51 for corrosion protection—chosen for its resistance to accidental exposure to petroleum products.

ROSKOTE MASTIC A-51 fully protects your underground metal even if exposed to petroleum products

Like all Roskote pipe mastics, this new oil and gasoline resistant coating is cold-applied by brush, spray or the Roskoter annular applicator. Roskote A-51 is a time-proven provider of high electrical resistivity and protection against corrosion by acid or alkali. Its fast drying permits prompt backfilling.

Effective above or below ground, A-51 provides superior cathodic insulation and protection against corrosive influences for other metal structures at terminals, bulk stations, natural gasoline plants and refineries. For complete technical data and prices, write the nearest Royston office.

Royston Laboratories, Inc.
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BRANCH OFFICES IN ATLANTA, CHICAGO, HOUSTON, PHILADELPHIA, SAN DIEGO AND TULSA. WAREHOUSED IN NORTHEAST, SOUTHEAST, NORTH CENTRAL AND SOUTH CENTRAL REGIONS.

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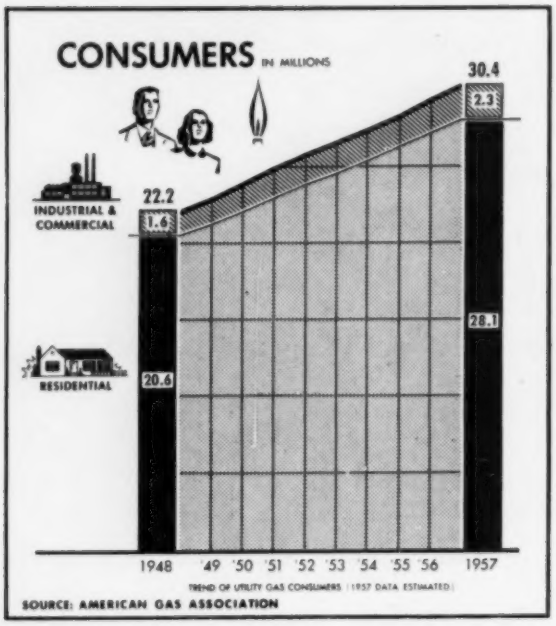
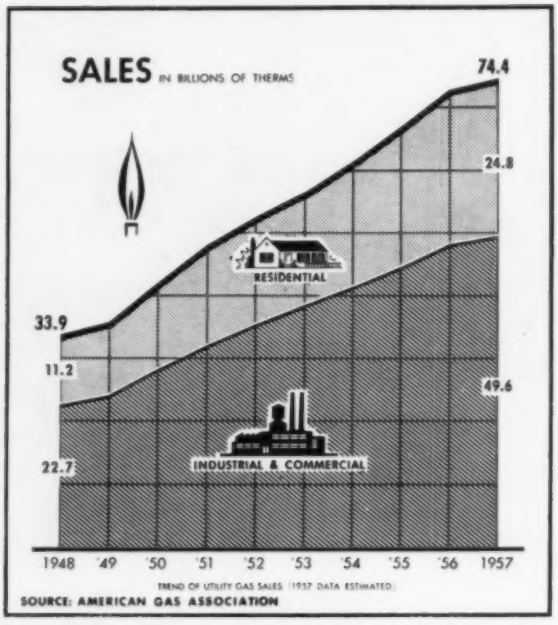


The gas industry is now serving 30,400,000 customers, but by 1970 expects to be serving 43,700,000, an increase of 45 percent.



In 1957 the gas industry sold 74.4 billion therms; by 1970 sales are expected to reach 153 billion therms, an increase of more than 100 percent.

Gas Transmission Pipelines Earmark More Money for Construction

First Quarter Reports and Special Survey Show:

- *Capital Expenditures UP 21% for 1958*
- *Operating Revenues UP 19% First Quarter*
- *Net Income UP 12% First Quarter*

Frank H. Love
Editor

AMID a generally jittery oil and gas industry picture, a brighter outlook is being provided by gas transmission pipelines.

First quarter reports from major systems, augmented by a private survey of *The Pipeline Engineer*, show:

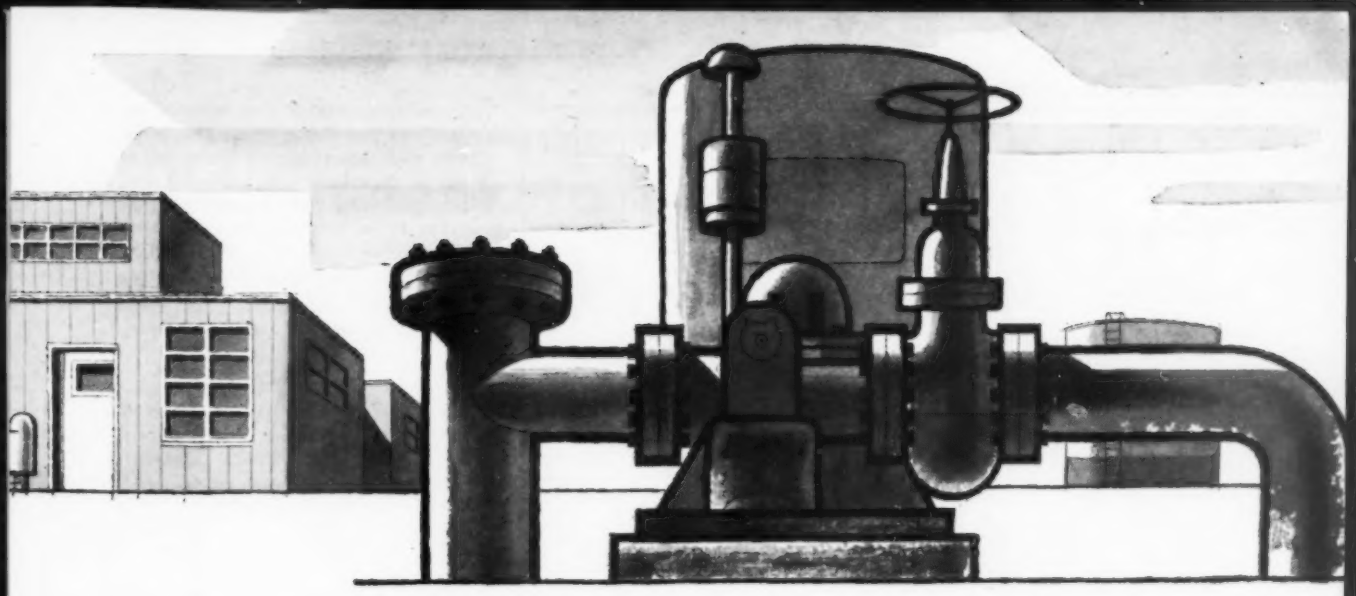
- **Operating revenues—up 19 percent.**
- **Net income — up 12 percent.**
- **Capital expenditures — up 21 percent.**

Capital expenditures are estimates by operating companies for the whole of 1958 as compared with 1957, whereas other percentages are for the first quarter of this year as compared with 1957's first quarter.

As most companies point out in their report, higher operating revenues are a natural result of expanded transmission facilities completed and placed in operation the latter part of 1957. Also, there have been some rate increases, the Memphis decision notwithstanding.

That net income did not increase in direct proportion to revenues indicates what is well known: Operating expenses also were up. Then, there is the further fact that some of the more recent purchases of gas were at higher prices to the producer.

Companies reporting said operating revenues totaled $754,242,981 the first three months of this year and $632,-143,493 for the same period of last year.



New PACKAGED Pipeline Control System cannot tell a lie!

Designed by the pipeline industry for the pipeline industry

NEW UNION C.T.C. FEATURES:

- Protection from error
- Unmatched reliability
- Easy expandability
- Modular construction
- Economy

For years, now, Union Switch & Signal has been designing custom control systems to solve individual problems for pipeline companies. Out of this experience has come a realization of your requirements and the need for a simple *standardized* system capable of easy expansion . . . with the lower-cost advantages of package design being passed on to you. That system is now available.

This new modular C.T.C. System concentrates all apparatus for the supervisory control of a station on two 19″-wide racks. One rack goes in the controlling office, the other goes at the field location being controlled. It provides display of indications and alarms and can easily be adapted to handle telemetering and other data. Future additions or changes to the system can be made without changing the basic circuits.

Security as well as conventional reliability

Rugged, industrial-type control components—designed and built by Union Switch & Signal itself—give this system the reliability you need in pipeline operation. But it goes further than mere reliability. Like other UNION C.T.C. Systems, this new system *checks itself* for error before implementing a control.

It is coded so that noise or distortion cannot operate the field equipment. It checks this code to insure correct operation. It immediately gives an indication if a power failure occurs at any time.

This is the system you need to insure fail-safe operation. It is the system you need to trim the cost of single station controls. Write for complete information. And watch for future standardized systems now being developed by Union Switch & Signal.

UNION SWITCH & SIGNAL

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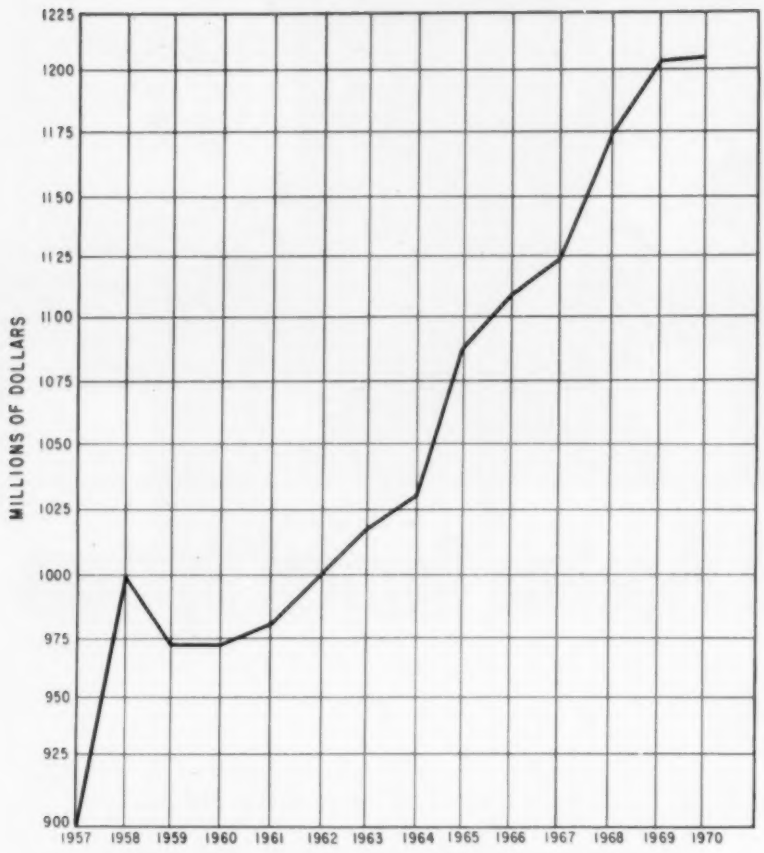


During the next 13 years the gas transmission industry will spend approximately $13,860,000,000 for new construction. This chart, based on American Gas Association statistics, illustrates the trend.

They said net income was $79,603,-110 this year and $71,010,032 last year.

Capital expenditures for the whole of 1957 were $926,833,790; estimates for 1958 are placed at $1,122,959,429.

Included in this analysis are the statistics only of companies who operate strictly as transmission systems, only four of which failed to provide *The Pipeline Engineer* with requested information. Thus, it should be emphasized that integrated systems having both transmission and distribution lines are not represented, as such companies do not break down their financial reports to provide separate data on transmission and distribution operations.

In view of the Memphis decision and the uncertainty it has engendered, it is quite a reversal of general thinking that capital expenditures should be scheduled to go above last year. Yet, this is what operating companies report. Some will spend less, it is true, but this deficit will be over-shadowed by the larger spenders, several of whom have earmarked close to, or more than, $100,000,000 each for construction in 1958.

These large expenditures, of course, make the big difference, and could reflect great courage on the part of these companies in going ahead and spending lavishly in face of the Memphis ruling. In some cases it does. In others it represents a forthright facing of the problem when it arose and the working out of a solution. The solution has been to obtain agreement of customers for a rate increase, as the Memphis decision requires. Other companies have been granted rate increases by the Federal Power Commission under bond, which will assure the customer of refund if the final decisions goes against the transmission company.

Among the companies who have negotiated rate increases with their customers are Texas Gas Transmission Corporation, Michigan Wisconsin Pipe-Line Company, Texas Illinois Pipeline Company, Natural Gas Pipeline Company of America, Tennessee Gas Transmission Company, Southern Natural Gas Company, and Transcontinental Gas Pipe Line Corporation.

What AGA Found Out

Others have been surveying the gas transmission outlook also, notably the American Gas Association. This large trade body has projected transmission pipeline expansion into 1970 and presents interesting statistics on the miles of line to be laid and the amount of money to be spent. Here is the AGA estimate of construction expenditures:

	Transmission (Millions)	Underground Storage (Millions)
1957	$ 910	$ 54
1958	990	67
1959	973	82
1960	973	68
1961	984	71
1962	991	74
1963	1,017	78
1964	1,029	82
1965	1,088	86
1966	1,108	91
1967	1,123	95
1968	1,173	99
1969	1,203	103
1970	1,206	108

The total to be spent on construction of gas transmission lines during the next 13 years, according to these figures, is $13,860,000,000, or an average of about $1,067,000,000 a year. Underground storage, an essential adjunct to the transmission company for peak shaving, will add $1,104,000,000 to construction expenditures during this period, or close to $85,000,000 a year.

For the $13,860,000,000 transmission companies will get a total of 103,-100 miles of pipelines, according to AGA, and these will increase yearly as follows:

Year	Miles of pipeline in operation
1957	157,300
1958	162,500
1959	168,800
1960	175,300
1961	182,300
1962	189,300
1963	196,900
1964	204,700
1965	213,200
1966	221,900
1967	230,800
1968	240,400
1969	250,400
1970	260,400

The AGA Bureau of Statistics estimates that by 1970 the gas industry will be serving 43,700,000 customers, 45 percent more than the 30,400,000 served in 1957. Sales of 153 billion therms in 1970 will be more than double last year's sales of 74.4 billion therms.

This will take a lot of gas and many miles of pipeline to deliver it. Transmission companies are looking far ahead and, obviously, are not letting any temporary difficulty deter them, not even this year with the outcome of the Memphis Case uncertain until this Fall when the United States Supreme Court will review the decision. ★ ★ ★

What it took to build the Westcoast Pipeline

It took more by far than most pipeliners realize. Here is a summary of materials and labor

WHAT'S IN A PIPELINE, and how does it get there? More — maybe a lot more — than most pipeliners realize.

Take a look at some of the endeavor, time, and materials that went into the Westcoast Transmission Company, Ltd., system that links the Canadian gas fields in the Peace River area with the Pacific Northwest of the U. S. and will quite likely extend on down into California.

Start it with a:

DREAM: All pipeline projects start with a dream —that of linking a large gas reserve with a large market. In this case the dreamer was Frank McMahon, president of Westcoast; the gas reserves those in the Peace River area (conservatively placed at 5 trillion cu ft with many sections still unexplored), and the market ready-made. Twenty years ago he visualized the linkage, then did something about it.

LEGAL SPADEWORK: Six years needed before authorization for construction obtained, with numerous hearings in Alberta, Ottawa, and Washington, D. C.

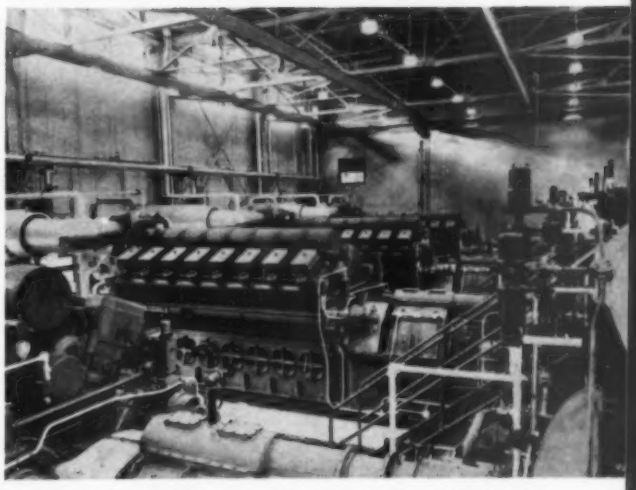
ENGINEERING: Engineering consultants — Ford, Bacon & Davis, Inc.
Agent and manager of construction — Canadian Bechtel, Ltd.
Subcontractors — Dutton-Williams Brothers, Ltd.; Construction Division, Canadian Bechtel; Conyes Construction Corporation; Mannix, Ltd.

DESIGN CAPACITY: 300,000,000 cu ft of gas per day in its initial operating phase, with future capacity of 660,000,000 cu ft per day when additional compressor stations are added.

MONEY: $195,000,000 for the first phase of construction, but an additional $100,000,000 expansion had been planned before the line even went into operation.

OBSTACLES: Below-zero temperatures, huge snow drifts, spring thaws, mountainous wooded terrain.

LABOR: During each of the two big building years a summertime peak of 2200 men were at work. Construction started October 1955; completed August 1957.



Compressor Station No. 5 near Australian, B. C., which has four spark-ignition gas engines. These engines have built-in speed increasing gears and drive single-stage centrifugal compressors. Eleven of these engine-driven centrifugal compressing units are in operation on the Westcoast Transmission Company gas pipeline.

MAIN LINE PIPE: 650 miles of 30-in. OD ⅜-in. wall API 52 LX pipe—total weight 230,426 tons.

DITCHING: Seven million tons of earth handled.

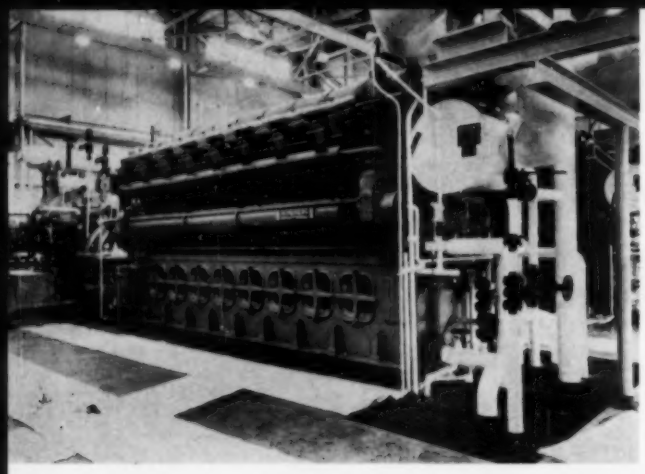
RIVER CROSSINGS: Seven major river crossings, six of them aerial. Bridge at Peace River—1675 ft between towers — is Canada's longest suspension bridge. In addition to the main line the span carries a 26-in. line bringing incoming gas from the Alberta fields to compressor station No. 1 at Taylor, B. C.

HIGHWAY AND RAILROAD CROSSINGS: 66 cased highway crossings, 41 railroad.

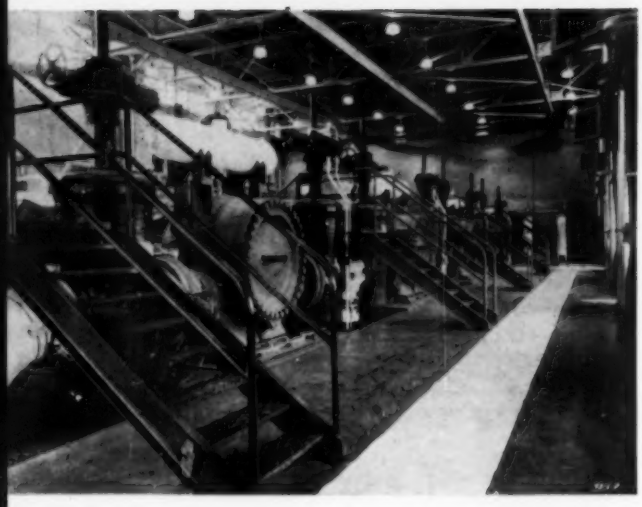
GATHERING SYSTEM: 155 miles of gathering lines lead into treating plant at Taylor, B. C.

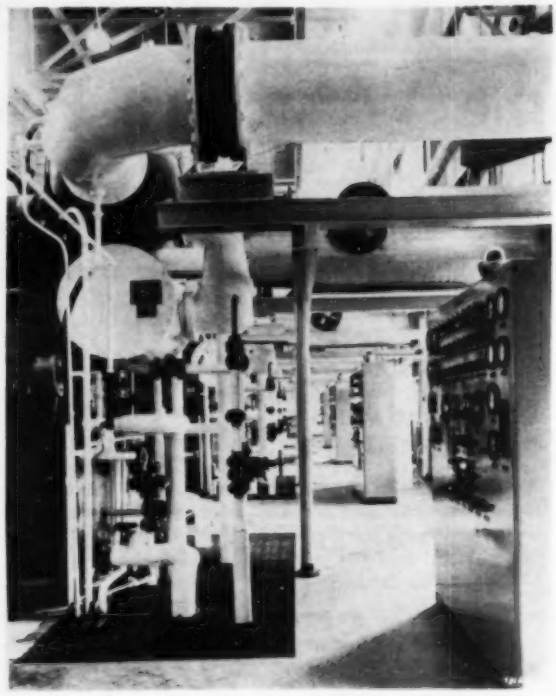
TREATING PLANT: Taylor $30,000,000 plant now the largest industry in this northern area. Also located here is compressor station No. 1 and a refinery built jointly by Pacific Petroleums, Ltd., and Phillips Petroleum Company for the manufacture of propane and a complete range of motor and aviation fuels. In addition, Jefferson Lake Sulphur Company has built a plant at this location to process the hydrogen sulfide into elemental sulfur at an initial rate of 300 tons a day.

COMPRESSOR STATIONS: Eight planned. Four (No. 1, 3, 5, and 7) constructed initially, so planned that intermediate stations can be built later



♦ This spark-ignition gas engine driving a single-stage centrifugal compressor through built-in speed increasing gears is rated 3500 bhp at 500 rpm at the installed altitude of 2300 ft.





Front end of spark-ignition gas engines. Note intercooler, turbocharger, and gage board with semi-automatic controls.

♦ Close-up of 24-in. by 24-in. single-stage centrifual compressors, which have a maximum working pressure of not less than 1000 psi.

and additional horsepower can be added to the existing stations as required.

Obstacles: All heavy equipment for two of the stations had to be trucked over a crushed stone road in below zero weather to beat the spring thaw. Four engines, for example, were individually placed on giant sleds and towed by tractors over the frozen highway to the station site at a pace of eight miles per day.

Engines and horsepower: Station 1: 6 single-stage reciprocating angle compressors, rated 2000 hp each, driven directly by 4-cycle gas engines running at 300 rpm. Stations 3, 5 and 7: Eleven spark-ignition gas engines in operation. Four engine driven centrifugal compressing units are installed at both stations 3 and 5. Station No. 7 has three units. The engines have built-in speed increasing gears and drive single stage 24-in. by 24-in. compressors. Each of these V-type engines have 16 cylinders of 13½-in. bore by 16½-in. stroke and are rated 3550 bhp at 500 rpm. The single step gear train has a 10:1 increasing ratio.

Water supply: Water from two wells each fitted with motor driven, deep well, turbine pumps.

Generators: Two 440-kw gas engine driven generator sets supply power for each station. Emergency power—40 kw propane gas engine driven generator.

Emergency fuel. A 500 cu ft propane gas storage tank. Propane can drive generators and air compressors when gas is off.

Cooling equipment. Atmospheric cooling sections, with 30-hp electric fans.

Building heat. A two-pipe hot water system with the primary source being heat from the engine jacket water. Also have boilers.

Engine controls: The gas engines driving centrifugal compressors are started and controlled at a point remote from the engine proper. These semi-automatic controls are designed for easy conversion to remote automatic.

Starting sequence. Before starting an engine, the operator checks the auxiliary equipment and turns the selector switches on the engine lube oil pump, crankcase vacuum pump, air filter pump, accessory lube oil pump, seal oil pump, auxiliary seal oil pump, discharge valve, and suction valve to automatic. Switches for standby equipment are turned to the "off" position. The operator then pushes the pre-start button on the engine board or the main console and the pre-start sequence is initiated.

Pre-start sequence. The crankcase vacuum pump, the air filter pump, the engine lube oil pump, start simultaneously. The accessory lube oil pump starts as soon as the oil temperature at the discharge of the accessory lube oil tank is at 90 F. When the oil from this pump reaches 20 psi, the main seal oil pump and the auxiliary seal oil pump begin operation. A pressure of 300 psi on the discharge side of the seal oil pump causes the auxiliary seal oil pump to shut down, and when the proper level in the seal oil tank is reached the unit by-pass valve opens to purge and pressurize the compressor case. After a time delay of 30 seconds, the unit vent valve closes and the compressor case is fully pressurized.

The discharge valve opens when a dif-

Front of station No. 5, showing 24-in. suction line and gas scrubbers, which remove all debris and liquids before the gas enters compressors. Note: Concrete partition between engine-compressor section (left) and rest of station.

Rear of station No. 5, showing (left to right) radiators, filter intakes, and exhaust silencers.

ferential pressure control senses zero differential across the unit suction valve. As the discharge valve reaches the 1-in. open position, the following are energized: The emergency shutdown controls, the alarm and shutdown annunciator system, the fuel solenoid valve, and the ignition control circuit. All intelligence devices, both alarm and shutdown, and all relays have been selected to give "fail-safe" operation.

The ignition is not on until after the engine is purged and the gas is turned on. When the discharge valve reaches the full open position, a "blue" light on the engine and console boards announces that the pre-start sequence is complete. This light will fail to come on if any of the steps in the pre-start sequence have not been completed. When the discharge valve is 1-in. open and the alarm and shutdown circuits are energized, any fault would be indicated on the engine board and if a shutdown device operates, the shutdown procedure would be initiated and the unit will return to complete shutdown condition.

The engine is started by the operator from the gage board. After the engine begins operation, the suction valve is opened by pressing either an inching button or a full open button.

Alarms. If an alarm intelligence device operates:

1. The "red" light on top of the engine board will flash;
2. An "amber" light on the engine annunciator panel will flash, indicating the source of intelligence;
3. The compressor unit master light on the main console will flash.

Simultaneously, an "on" and "off" signal is given by a howler in the compressor room and auxiliary wing and by a buzzer in the main control room. If the operator can rectify the faulty condition, the intelligence circuit will re-establish itself and automatically turn "on" the "amber" light on the engine board.

If a shutdown intelligence device operates:

1. The "red" light on top of the engine board will go "out";
2. A "red" shutdown light on the engine panel will come "on", indicating the source of shutdown intelligence;
3. The unit light on the main console will go "out."

Simultaneously, a continuous signal will be given by the howler and buzzer. The other shutdown annunciator lights will be locked out, the alarm lights will go "out", and the shutdown sequence of the engine will be initiated. The annunciator panel remains locked, showing the cause of shutdown, until the opening of the discharge valve in the next pre-start cycle unlocks it and inserts the alarm and shutdown devices into the shutdown circuit. The above procedure is identical at all three centrifugal compressor stations.

Engines for station No. 3 were hauled by sled over the frozen John Hart Highway on the last leg of their trip from Milwaukee, Wisconsin. The 75-mile haul was made at a pace of 1½ mph in below zero weather. Three tractors combined their power to move the sled and another scraper-equipped tractor was ahead, moving snow onto bare spots in the road.

Future

The demand for this new source of fuel is so great that a $100,000,000 addition was planned even before the line was finished. Ultimately, some stations will have as many as six engine-compressing units and the line's capacity will be increased by more than 50 percent. In its initial operating phase, the Westcoast line is delivering 300,000,000 cu ft of gas per day. When additional compressor stations are added, its capacity will be increased to 660,000,000 cu ft per day.

Much of this added output will go to Pacific Northwest, which has contracted for an additional 350,000,000 cu ft of surplus gas a day. In addition, both the British Columbia Electric Company, Ltd., and Inland Natural Gas Company, Ltd., distributors for British Columbia areas, have exercised their options to take substantially larger volumes.

Acknowledgment

Thanks are expressed to the Publicity Department of Nordberg Manufacturing Company, manufacturers of the Supairthermal spark-ignition engines, for material contained in this article. ★ ★ ★

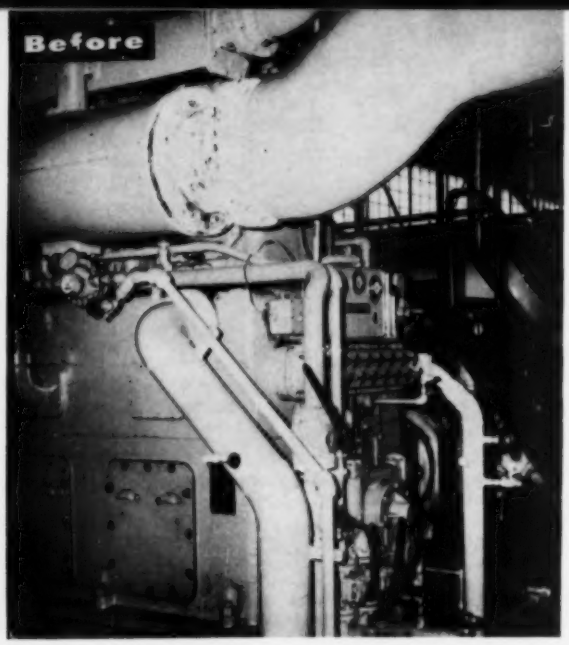


FIG. 1. Exhaust end of HBA before conversion. Objective — increase hp from 1760 to 2050.

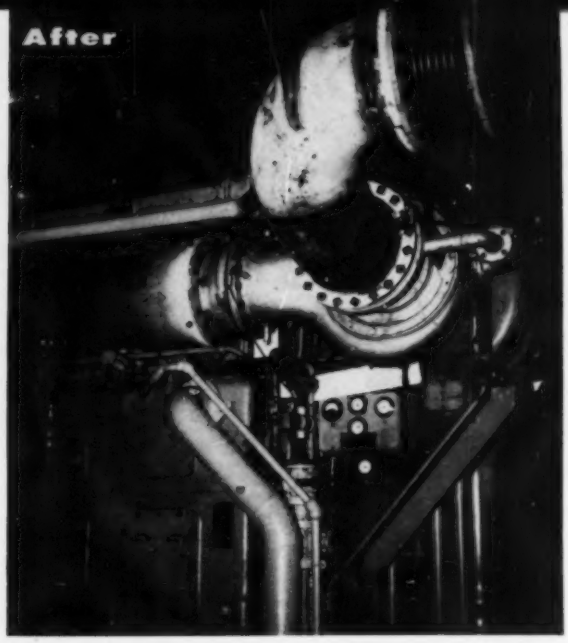


FIG. 2. Same engine in the final stages of conversion. Turbocharger has replaced scavenging air cylinder.

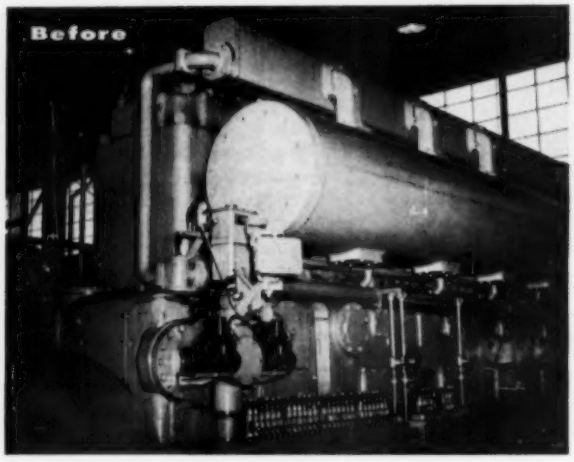


FIG. 3. Flywheel end before conversion. Note water-cooled exhaust manifold.

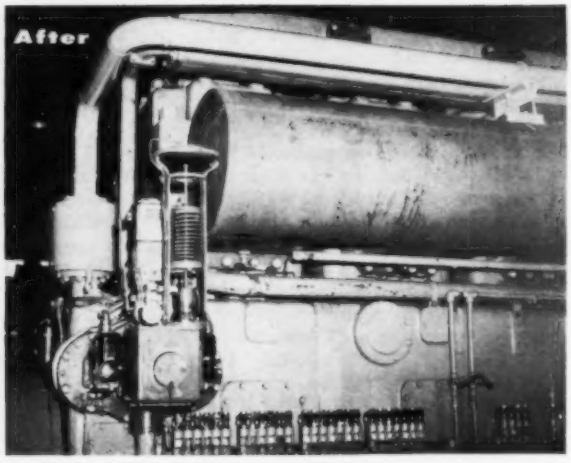


FIG. 4. Same engine with dry manifold (which saves heat for supercharger).

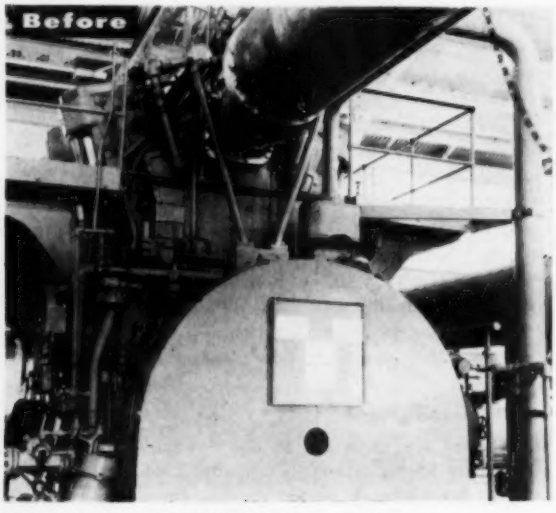


FIG. 5. Flywheel end of GMW before conversion.

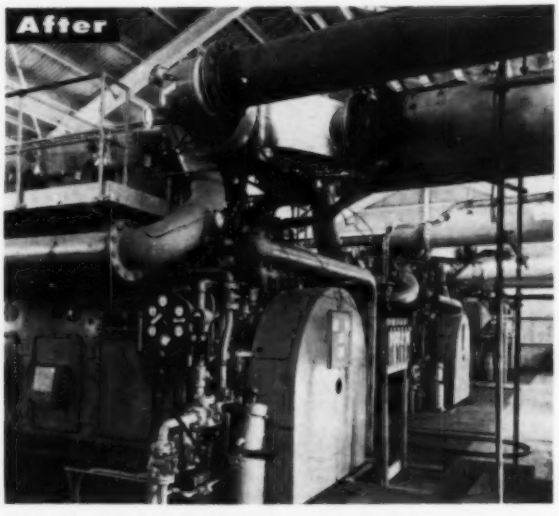


FIG. 6. Same end. Turbocharger has been added.

How to increase Hp 17 to 40%

P G & E field supercharged gas engines and not only upped the horsepower but also the fuel efficiency

by Kenneth B. Anderson
General Superintendent Technical Services, Pacific Gas and Electric Co.

THE IDEA OF GAINING added horsepower by supercharging in the PG&E system came about through the lack of space in one of our stations to accommodate growth somewhat beyond that anticipated when the system was planned.

Background

In 1951 a 500-mile transmission line was completed from Topock, California, where it connects to the El Paso Natural Gas Company system, to the San Francisco Bay area. Originally designed for 400 MMcf per day with a single 34-in. line and 44,120 hp, it has grown in six steps to an expected capacity of over a billion cubic feet this year with a fully looped 34-in. line and 87,000 hp.

In 1955 it became apparent that the ultimate growth would create a space problem at Topock as may be seen from the airplane view (Fig. 9). This situation required consideration of the possible courses open. Among these, the recently available conversion of existing Cooper-Bessemer GMW 2500-hp units to GMWC 10 3500 hp offered a solution of the space problem as well as promising some improvement in fuel economy.

While at first glance the conversion of existing units would seem to be much cheaper than installing new ones, when everything is considered, the need for cooling combustion air, the compressor cylinder changes to absorb the added power and changes in the piping, cooling and scrubbing — which are functions of gas handling rather than number of units — the saving in first cost boils down to the building, the engine foundation and piping. Coincidentally, the conversion parts cost was about the same per horsepower as new units.

The saving in fuel consumption was estimated at seven percent as a result of the substitution of exhaust driven turbochargers for the shaft driven scavenging pumps on the two cycle engines.

Although primary motive for conversion at the Topock station was space saving the incidental benefits seemed worthwhile in the other stations where more horsepower was needed.

The stations as they existed before conversion consisted of nine hp Cooper-Bessemer GMW 10's at Topock; 10 similar ones (but altitude derated to 2400 hp) at Hinkley; and eight 1760 hp Clark HBA 8's and four 1420 hp Ingersoll-Rand KVG 12's at Kettleman. The plan is to convert all eight of the Clarks from 1760 hp to 2050 hp by turbo-charging, and to convert 12

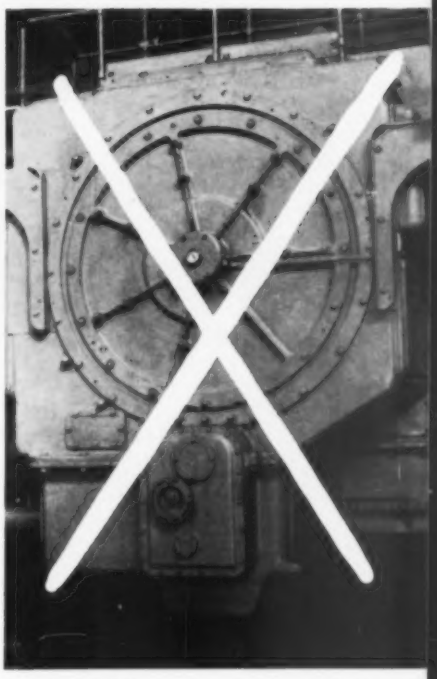


FIG. 7. Oscillating scavenger blower that drove off crankshaft was replaced by turbocharger driving off the heat of engine exhaust.

FIG. 8. (Below) Note the increases in fuel efficiency along with horsepower increases.

COMPARISON OF SUPERCHARGED AND UNSUPERCHARGED ENGINES

	KETTLEMAN STATION		TOPOCK STATION	
	AS INSTALLED	SUPERCHARGED	AS INSTALLED	SUPERCHARGED
HORSEPOWER RATING	1760	2050	2500	3500
B.M.E.P. - P.S.I.	75.5	87.7	77.8	108.9
FUEL RATE BTU / H.P. HR.	8000	7500	7500	6950
FIRING PRESSURE - P.S.I.	530	550	700	800
EXHAUST TEMP. MANIFOLD °F.	585	870	680	850
SCAVENGER AIR PRESS - IN. Hg.	3.5	12	5	12
SCAVENGER AIR VOL. CU. FT. / MIN.	7000	9500	11000	16500
HEAT REJECTION B.T.U. / H.P. HR.				
TO JACKET WATER	2300	1500	1725	1200
TO LUBE OIL	550	470	430	350
TO AFTERCOOLER	220			340

of the 19 Coopers from 2400 or 2500 hp to 3500 hp by replacing existing oscillating scavenger pumps with two stage centrifugal scavenging, the first stage, exhaust turbine driven—the second stage—belt driven from the crankshaft.

At the present time we have completed all of the Clarks and three of the Coopers. Cost data is incomplete but an analysis indicates that the overall cost of conversion in this particular situation is very close to 88 percent of the cost of new equipment on a horsepower basis. This, of course, is an integrated plant cost — the engines alone would show a better ratio.

It may be interesting, for those of you who may be considering similar conversion, to discuss some of our experiences:

FIG. 9. Reason for conversion originally was shortage of space at Topock station.

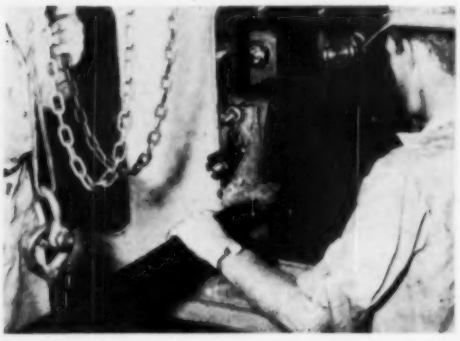


FIG. 10. Installing new crankshaft counter balance on 1760-hp engine after removal of scavenging cylinders.

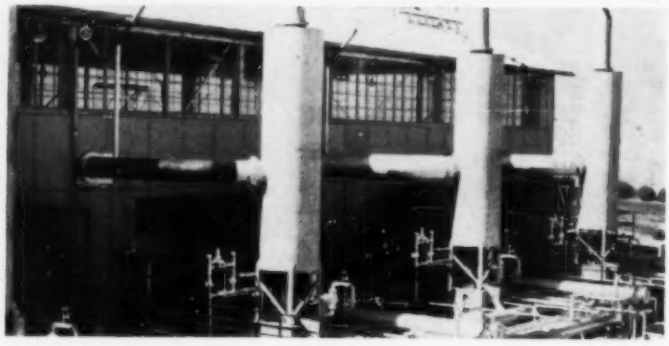


FIG. 11. Mufflers after conversion. Note lagging on farthest two.

Converting the Clark HBA-8's at Kettleman

The changes necessary on these units are broadly as follows:

Remove scavenging cylinders and install crankshaft counter-balance and crank spacer to compensate for removed parts (Fig. 10).

Replace water cooled exhaust manifold with dry manifold to conserve heat for turbocharger (Fig. 3 and 4).

Add large diameter exhaust pipe in a new location. The muffler internals are removed and a new larger, and relocated entrance nozzle installed (Fig. 11).

Replace governor and ignition drive to provide means of retarding spark (Fig. 4). New, larger capacity magnetos were installed and an additional coil and spark plug fitted to each cylinder (Fig. 12).

Install turbocharger and supporting bracket on engine opposite flywheel end (Fig. 1 and 2). Considerable instrumentation is required to control energy to turbo-charger. This involves starting air at 80 psi to start turbocharger, retarding mechanism to increase exhaust energy during starting and heavy load, exhaust by-pass around turbocharger, hand operated oil pump to oil turbocharger before starting, fuel gas cut off responsive to excessive scavenging pressure to prevent turbocharger over speed, and various thermometers, manometers, and pressure gages.

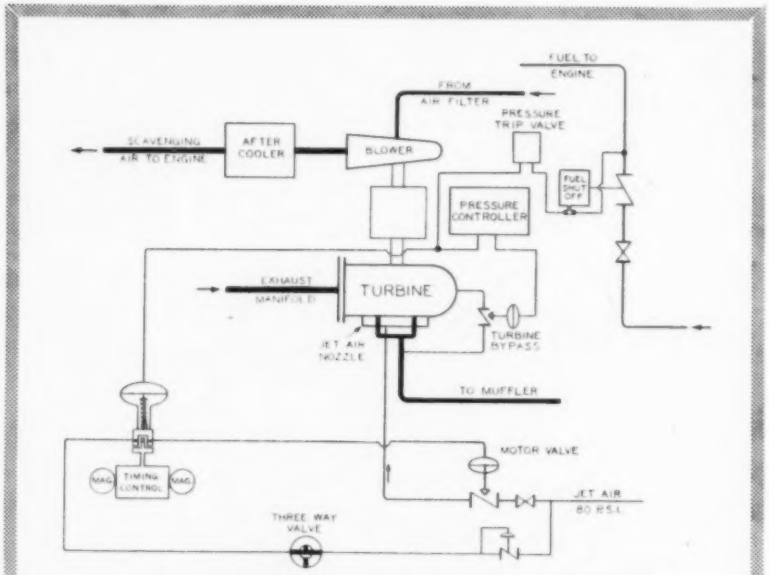


Fig. 12. Schematic Diagram of Jet Air Controls on Clark HBAT Starting Procedure.

250 PSI engine starting air is timed and engine starts to rotate. Three-way valve on jet air control line is in "start" position as shown.

When the engine is rotating, the timing control retards the spark to 40° ATC and admits control air to jet air motor valve, which in turn admits 80 PSI air to turbine starting jets.

When the turbine has caused the scavenging air manifold pressure to start to rise, the ignition is turned on and the gas throttle valve cracked until the engine begins to fire.

The air starting valve is then closed, and the three-way valve in the jet air control line turned to the "run" position.

When the scavenging air pressure exceeds 7 in. Hg, the timer control starts to advance the spark. When air pressure reaches 11 in. Hg., the spark has been fully advanced to 12° BTC.

If the scavenging pressure exceeds 15 in. Hg, the turbine by-pass starts to open.

If, for any reason, the scavenging pressure reaches 20 in. Hg, the pressure trip valve closes the fuel shut-off valve.

Replace and relocate air intake and scavenging piping to provide larger capacity with less pressure drop, greater plenum capacity, provisions for after cooling the scavenging air after compression, and relocation of the crankcase breather. This latter was carried into the scavenging pump suction before, but it was felt that if introduced into the centrifugal unit an accumulation of foreign matter might result in unbalancing the wheel. The breather was therefore piped to the outside of the building.

This breather arrangement, together with the higher pressure level of the cycle, results in somewhat higher crankcase pressure with consequent greater demand on crankshaft seals and crankcase gaskets.

Half of the engines had low compression power cylinder heads. It was necessary to replace these with high compression heads.

The turbocharger is not only sensitive to pressure losses both on the suction and exhaust sides, but also to mechanical forces from the air and exhaust piping. The design of the latter must include expansion provisions and supports which confine these forces within allowable limits (Fig. 13).

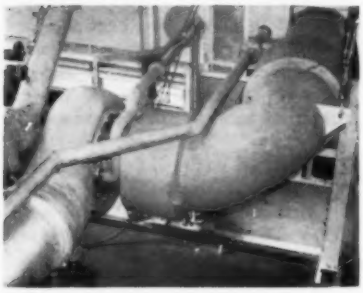


FIG. 13. Exhaust piping, showing lagging and hanger.

The most difficult and time consuming part of the conversion concerns the installation of the controls and air starting equipment for the exhaust turbine. A rather complicated system is required to get the turbine started and to control the energy available to it during operation (Fig. 12). **For many months we had difficulty in starting the engines and only recently has the technique been perfected. The secret, aside from critical adjustments, is to approach the starting as two separate but interrelated procedures — one to control the energy to the turbocharger — the other to get the engine proper started and up to a speed where the system is in balance. Under favorable conditions it takes as much or more starting air to start the turbine as it does to roll the engine** (Fig. 15).

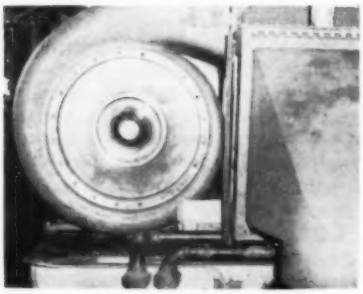


FIG. 14. Turbocharger with air intake piping removed to show rotor.

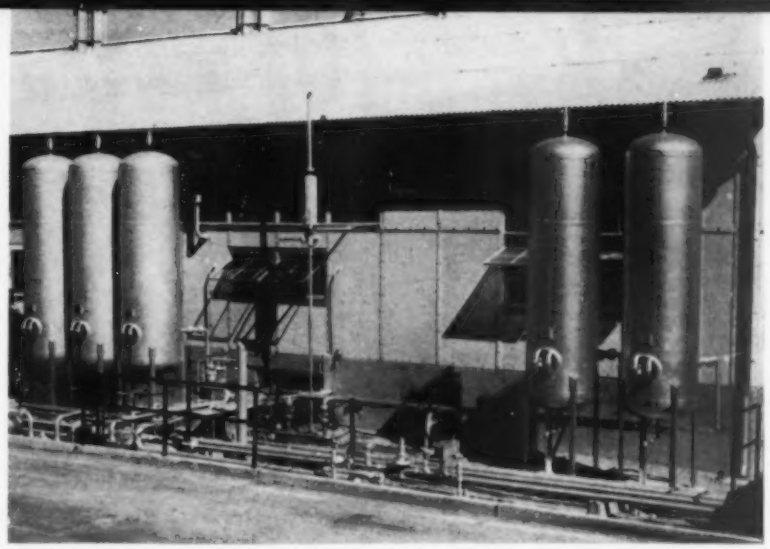


FIG. 15. Additional starting air tanks were provided for starting supercharged engines.

Since the turbine must be started before the engine is running, it was felt that some provision should be made for building up the lubricating oil pressure before starting. Provision had been made for maintaining oil pressure during the coating period after stopping the engine and finally a hand pump was provided for the initial pressurizing.

There seem to be differences in opinion as to the need for checking turbocharger rotor speeds, as the manifold pressure in itself is a function of turbine speed. We felt, however, that provisions should be made for checking the rotor speed independently and designed two windows, one for the strobe-light, one for visual observation, in the air inlet elbow (Fig. 16).

FIG. 16. New scavenging air intake piping. Note provision (at left) for checking rotor speed with stroboscope.

In order to absorb the 17 percent increase in horsepower 11¼-in. liners were removed from the four compressor cylinders making the cylinders 12¼-in. in diameter.

Converting Cooper-Bessemer GMWC 10's at Topock

The conversion of these units is complicated by the necessity of replacing the oscillating type scavenging blower with a centrifugal compressor, belt driven from the engine crankshaft. GMW's had been converted to the centrifugal scavenging before in other plants and had been scavenged with exhaust driven turbochargers. Moreover, new units had been built with gear-driven centrifugal combined with exhaust driven turbochargers, but no combination such as ours had been attempted before.

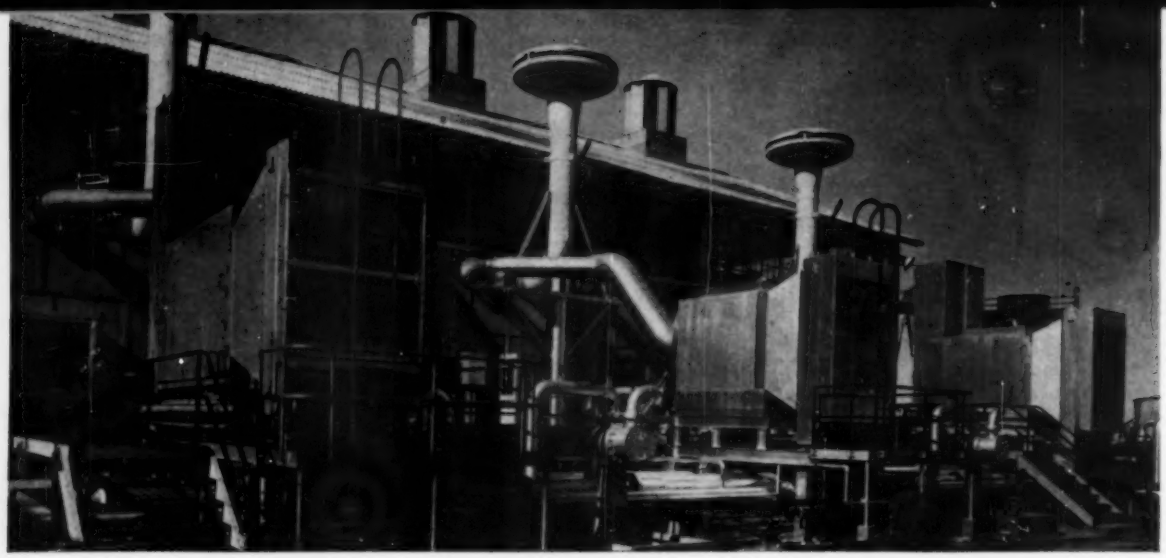


FIG. 17. Converted units at Topock. Intake air coolers and humidifiers are in the foreground. Note the new exhaust mutes on engines 9 and 10.

The changes include the following:

Remove oscillating blower (Fig. 7) and replace with belt driven centrifugal (Fig. 18).

Replace power cylinders with porous-chrome plated cylinders.

Remove water cooled exhaust manifold and replace with dry manifold, turbochargers and air piping connecting first and second stage compression (Fig. 5 and 6).

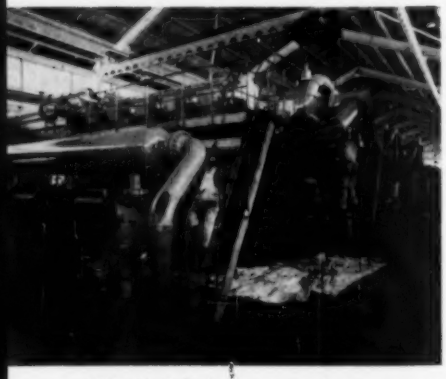


FIG. 18. Belt driven scavenging compressor provides second stage air compression. This was taken during latter stages of conversion.

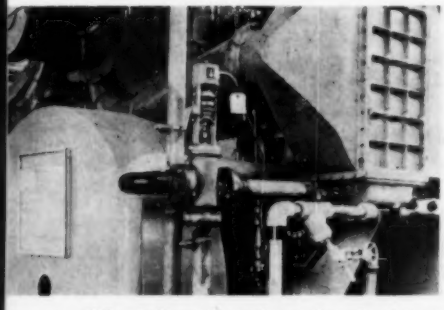


FIG. 19. New aftercooler and combustion air temperature controller (3-way valve).

Remove intake air piping and air filters and replace with larger air filters and air coolers for precooling and humidifying combustion air (Fig. 17). An after cooler (Fig. 19) is also installed between the second stage compressor and the engine plenum chamber.

Replace exhaust piping and relocate muffler (Fig. 17).

Relocate jacket water piping and headers to clear revamped engine parts.

Install instrumentation such as thermostatic control of after-cooler water and indicating instruments for temperature and pressure on added functions.

In order to absorb the 40 percent increase in horsepower two of the three compressor cylinders are increased from 13 to 16-in. diameter. This requires redesigning the cylinder cold supports, revamping the cylinder connections to the pulsation dampeners on both suction and discharge as well as the internals to handle the increased volumes, — more on this later.

The 48 in. two-pass mufflers were judged suitable for the converted engines. Their location, however, was not compatible with the design of the precooling and filtering equipment. At first it was reasoned that the pressure drop and equalizing effect of the exhaust turbines would make an open exhaust feasible. One of these units is shown in Fig. 17. A trial revealed, however, that while local sound was not offensive, a low pitched rumbling noise caused complaints from residents a half mile or more distant. Two Everett mutes (shown in Fig. 17) were tried. While these can no doubt be made to serve, the economics favor relocation of the original mufflers with some minor redesign of the air piping (Fig. 24).

The greatly increased horsepower of the engines requires both precooling and aftercooling of the combustion air under the ambient conditions prevailing in that locality much of the year. Use of the air precooler as a combination source of cool, moist air and cool water for the after cooler provides an attractive heat balance at reasonable cost.

At first we were troubled with liquid water carryover into the engines. With the high chloride and solids content of the local water, this gave cause for concern, partly due to the residual solids deposited in the engine, and partly to the corrosion products of the air piping which had received only normal internal treatment. Increasing the demisting facilities as shown in the first and third units on Fig. 17 and employing a more effective internal treatment of the air piping has removed most of the objections from these sources. Some tower maintenance is anticipated however unless a source of better water is developed.

Early in the tests it was found that the water flow to the two aftercoolers must be equalized and controlled or condensation could occur in the air to the engines. Three way valves responsive to the air temperature going to the engine permit control of the air temperature through by-passing the cooling water around the aftercoolers, at the same time permitting full flow of water over the precoolers (Fig. 20).

Many of the air cooling problems became apparent after the installation of the new GMWC 10 and hence were well on the way to solution before conversion of existing units was started.

In connection with the pulsation dampeners, as mentioned before, the

most economical step was tried first, namely removing the internals of the suction dampener and revamping the connections to fit the new cylinder sizes. This expedient appears to be satisfactory both from a pressure drop and a pulse standpoint, as no objectionable vibration of piping has occurred on the suction side. The discharge dampeners were removed as above except that the internals, instead of being removed, were modified for the increased flow. While these performed as well as the original, the pressure drops, pulses, and allowable working pressures were not up to the standard we are striving for. New discharge pulsation dampeners have been ordered for all converted units, and if units are expected to remain unconverted for an indefinite period, perhaps these too will be replaced with more effective equipment.

The air filter installed originally is adequate in design but insufficient in area for the demands of the converted units. It is planned to add one more section to provide the needed area. In order to provide the needed sections, the first three conversions at Topock have been fitted with new units. The removed units will then provide the sections needed for the next six units.

One of the puzzling problems that has arisen as a result of the conversions is the effect on the crankshaft alignment. Crankshaft deflection readings have been taken on each unit before conversion; after removal of parts; after installation of new parts, and after a period of operation in the converted state. The tendency for the ends of the shaft to deflect upward during this sequence has given cause for concern. How far the deflection will progress, the permissible deflection, its cause and correction, are the subject of current study.

Operating Results

Working out bugs. Experience indicates that while the first unit requires considerable time both to acquaint the erection forces as well as to work out "bugs," the ultimate program is about three weeks per Clark HBA and about six weeks per GMWC 10.

Maintenance. Sufficient experience has not been gained to tell much, quantitatively about maintenance. We have reason to believe, however, that the maintenance cost per horsepower on the turbocharged units will not exceed that previously experienced on the unturbocharged units. Such additional maintenance as is required on the turbochargers themselves, the air cooling equipment, and the added instrumentation should be lost in the greatly increased horsepower per unit ratio.

The converted engines operate smoothly and seem comfortably able to handle as much or more overload, in proportion, as the unconverted engines.

Fig. 8 shows comparative characteristics of the turbocharged and unturbocharged engines.

The following table shows quantitatively some of the operating pressures and temperatures observed during tests. These figures are not intended to be final but do indicate the order of magnitude of some of the values.

	Cooper Bessemer GMWC 10	Clark HBA-8
HP Fuel	3518	2037
Btu/hp	7070	7712
Exhaust Turbine:		
Inlet temp F	710	939
Inlet pres in. Hg	7.5	8.7
Outlet temp F	638	832.5
Outlet pres in. H_2O	5.1	3.1
Scavenging System:		
Inlet temp F	102	78.4
Inlet pres in. H_2O (vac)	6.4	2.9
Outlet temp F	169	153
Outlet pres in. Hg	12.5	12.6
After Cooler		
Inlet temp F	169	153
Outlet temp F	105.4	123
Precooler:		
Inlet temp F dry bulb	102	
Inlet temp F wet bulb	64.5	
Outlet temp F dry bulb	80.9	
Outlet temp F wet bulb	80.9	
Inlet water temp F	88.5	
Outlet water temp F	79.9	
First Stage Blower:		
Outlet pres in. Hg	7.0	
Outlet temp F	140	

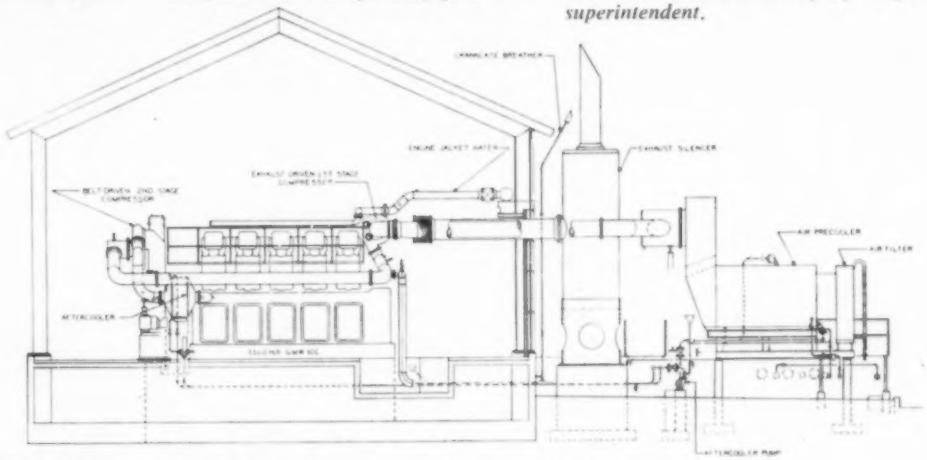


FIG. 20. Schematic arrangement of conversion of 2500-hp engines to 3500.

ABOUT THE AUTHOR

Kenneth B. Anderson *has been general superintendent of Technical Services for PG & E since 1954. He graduated from the California Institute of Technology in 1924 in mechanical engineering, then spent a year with General Petroleum Corporation. In 1925 he went with the industrial sales department of Southern California Gas Company and in 1929 he went with Coast Counties Gas Company as gas superintendent.*

Acknowledgments

Guy T. Martin has acted as consultant and has handled the design and drafting work in connection with the conversion work and other plant expansion. The actual conversion work has been handled by PG&E's general construction department which has afforded much more flexibility in the programming than is ordinarily possible.

Raymond C. Baird, has been engaged to analyze noise, pulsation, and vibration in the plant in order that corrective measures can be incorporated as the conversion program continues.

During the study phase of this project, **John Talbot** of Tennessee Gas Transmission was kind enough to show us around his Greenville, Mississippi, plant where a Clark HBA 6 had been operating supercharged, and his Batesville plant with single stage turbocharged Coopers, and **F. B. Haverfield** of Transcontinental Gas Pipe Line Corporation, showed us his El Campo plant with Coopers equipped with belt driven centrifugal scavengers. The cooperation of these gentlemen is sincerely appreciated.

Clark and Cooper engineers have devoted a great deal of time and effort to make our conversions a success. We are confident that this will eventually be attained.

The patience and cooperation of **E. H. Fisher** and our own operating people is also appreciated. They have been able to continue operating the plants at considerably above rated capacity in spite of the confusion and disturbance of the conversion process. ★ ★ ★

RUSSIA is making an all-out bid for gas reserves

Timetable calls for 270-320 billion cu m sometime between 1967 and 1972, with commensurate pipeline construction

Charles L. Adams

RUSSIA is in the first stages of a government-decreed, long-range program for "shock-tempo" development of the nation's natural gas resources.

New Soviet plans call for a "13 to 15-fold increase in gas production within the next 10 to 15 years." Currently, production is increasing by more than 50 percent annually. Exploration and pipelining activity have been stepped up sharply.

From a meager 6,181,000,000 cu m* in 1950, Russian gas production increased to 10,356,000,000 cu m in 1955, to 13,678,000,000 in 1956, and to 20.2 billion in 1957. A 52 percent jump to 30.7 billion cu m is planned for 1958.

Soviet Premier Nikita Khrushchev has set an overall gas production goal of 60 to 65 billion cu m in 1960, including at least 56.5 billion cu m of natural gas, and 270 to 320 billion cu m some time between 1967 and 1972. The latter figure comes close to U. S. natural gas output for 1957.

Last year, gas accounted for 4.2 percent of Russia's total fuel output, compared with 2.4 percent in 1955, and 1.7 percent in 1940. By 1965, gas is scheduled to represent 17.2 percent of Soviet fuel production (in equivalent units), and by 1972 the figure is to rise as high as 25 percent.

In 1956, gas was being supplied to 1,315,000 residential meters in 99 Russian cities. This represented 13.8 percent of the USSR's urban population.

By the beginning of 1959, the Soviet Union expects to be providing gas for 1,750,000 residential meters in 150 cities — or 18 percent of the urban population.

Looking still further ahead, Russia hopes to supply gas to about 500 cities and towns and to 35 percent of its entire population by 1965, the latter total including rural liquid gas consumers.

Soviet economists emphasize that the cost of extracting natural gas in European Russia "is, in equivalent units, 12 times lower than for extracting coal in the same region. It is obvious," they add, "that the cost of natural gas, even where it is transmitted 1500 to 2000 km**, is many times cheaper than any other type of fuel in the European part of the USSR and only in the Urals is costlier than local, high-sulfur mazut (residual oil).

"When one considers that the combined cost of extracting and transporting coal in European Russia is about four times higher than extracting and transporting equivalent units of natural gas, it is apparent that using gas can provide a saving of about 10 billion rubles ($2.5 billion) in 1965 alone."

Russia's sixth Five-Year Plan (1956-60) for pipelines.

*1 cu m equals 35.314 cu ft.

**1 kilometer equals 0.62137 mile.

Welder at work on Stavropol-Moscow gas pipeline.

The USSR frankly admits that its gas industry has been — and still is — sadly underdeveloped. One of the main difficulties, the Russians explain, has been the poor organization of gas exploration work.

According to the magazine *Planovoye Khoziaistvo (Planned Economy)*, official organ of the USSR's State Planning Committee, "exploration for gas fields was practically non-existent in our country before 1942. Gas was discovered incidentally in the search for oil.

"In most cases, oil exploration personnel did not carry their work to a logical conclusion after finding what they believed to be a purely gas strike. Instead, the drilling crews moved on to other structures."

First major natural gas exploration activity in the USSR took place in 1942 following discovery of the Elshanka field near the Volga River north of Saratov. In 1942-1943, a short gas line was built from Elshanka to Saratov.

First Gas Line in 1943

The USSR's first natural gas line of any distance, extending 87 miles from Buguruslan westward to Kuibyshev on the Volga River, was also completed in 1943.

When the Russians decided to tap the Elshanka field with a 525-mile pipeline from Saratov to Moscow, they ordered extensive exploration both in Saratov Province and in Stalingrad Province to the south in order to insure an adequate gas supply for the new system. The 300-mm (12-in.) Saratov-Moscow line went into operation in 1946.

With the end of World War II, gas exploration also got underway in the Carpathian Mountain area of the western Ukraine near the Polish and Czech borders. Opening of the large Bilche-Volitsa, Ugersk, and other fields, together with increased exploitation of the Dashava field, provided enough reserves to permit construction of the 319-mile Dashava-Kiev pipeline in 1951. This 500-mm (20-in.) line was later extended to Bryansk and Moscow, making a total length of about 800 miles.

Most significant Russian natural gas discovery in the post-war period has been the prolific North Stavropol field in the foothills north of the Caucasus Mountains. Gas reserves in the Stavropol area are believed to be the largest in the Soviet Union. By 1960, Stavropol's output is slated to reach 12.6 billion cu m annually.

According to Russian reports, the Stavropol gas wells are "the most productive in the world." The gas is said to be "of the highest quality, does not cause hydrogen sulfide corrosion, and does not require special purifying when processed into chemical products."

An 807-mile pipeline from Stavropol to Moscow was officially completed late in 1956, although it is still far from ready for use at rated capacity. This 720-mm (28-in.) system – longest in the USSR and in Europe as well — is being equipped with microwave instead of conventional wireline communications.

When the second Stavropol-Moscow line (now under construction) is completed, the Russian capital will be getting 20 times more Stavropol natural gas than it receives from the small-diameter Saratov-Moscow link. Within three years, most of Moscow's industrial plants will be operated on natural gas. In 1960, the city will receive 10 billion cu m of gas—five times as much as in 1956.

Moscow (population of 5,000,000) expects gas to supply 70 to 90 percent of its fuel needs in 1960. Coal requirements will be cut seven-eighths and will represent "not over 8 percent of the capital's fuel consumption."

Besides Moscow, Stavropol gas is, or soon will be, going to such cities as Rostov, Taganrog, Zhdanov, Novocherkassk, Shakhty, Voroshilovgrad, and Voronezh. A large number of new chemical plants — for production of nitrogen fertilizer, carbon black, artificial fiber, plastics, etc. — are being built or planned in the northern Caucasus area to take advantage of the abundant gas supplies.

Although Russian gas exploration increased sharply after 1942, it was still concentrated almost exclusively in areas close to proved fields. Throughout the remainder of the USSR, oil and gas exploration was carried on jointly.

Gas Exploration Pushed

Seeing that under these conditions natural gas resources would be limited, the Russian government in 1956 and 1957 made special provision for independent gas exploration. This move, according to *Planovoye Khoziaistvo*, "quickly provided positive results."

In 1956-57, the publication reports, "many new natural gas fields were discovered. As a result, our increase in natural gas reserves was 3.5 times as great as in 1950."

Russia drilled 350,000 meters† of "deep" exploratory gas wells in 1956, representing 14.8 percent of all Soviet exploratory drilling for oil and gas combined. Estimated deep exploratory gas drilling in 1957 was 575,000 meters, or 19.2 percent of all exploratory drilling.

Deep exploratory gas drilling goal for 1958 is 868,000 meters, or 23.5 percent of all Soviet exploratory drilling for oil and gas.

During 1956 and the first 10 months of 1957, Russia claims to have discovered 27 new gas fields having reserves totaling "several hundred billion cubic meters." This brought the total number of gas fields in the USSR to about 160 by the end of last year.

"Commercial reserves in these fields already permit doubling or tripling cur-

Stringing pipe on the Stavropol-Moscow gas line.

rent natural gas production," the State Planning Committee asserts.

The New Fields Are Here But . . .

New fields discovered in recent years are in the eastern Ukraine, on the east bank of the Volga River, in the northern part of the Krasnodar district (east of the Azov Sea), in western Siberia around Berezovo, in the Bukhara-Khivinsk district of Central Asia, and in Azerbaijan. Some gas also has been found in the Ust-Vilyui area of Yakutia, north of Irkutsk, and elsewhere in eastern Siberia.

Proved gas reserves are said to be "tens of times" greater than before World War II, with 85 percent of the commercial reserves located in 12 large fields. One-third of total Russian reserves are concentrated in the North Stavropol (northern Caucasus foothills), Shebelinka (eastern Ukraine) and Karadag (Azerbaijan) fields, which are, in terms of the USSR's total area, relatively close together.

Last year the State Planning Committee directed the All-Union Natural Gas Scientific-Research Institute to evaluate the nation's potential natural gas reserves. A preliminary report states that these potential reserves are "enormous."

. . . Future Exploration Will Be Here

Between 1959 and 1965, Russia expects to concentrate exploratory natural gas drilling in the northern Caucasus, the western and eastern Ukraine, Azerbaijan, the Volga River area, Central Asia, the Komi Autonomous Republic (far northern Russia west of the Ural Mountains), and in northern Tyumen Province (western Siberia). These regions also will account for the planned increase in gas production through 1965.

To ensure the necessary output and reserves, "deep" exploratory natural gas drilling will total 10 to 12 million meters between 1959 and 1965. As compared to 575,000 meters of deep gas wells drilled in 1957, plans call for 2.2-2.4 million meters in 1965 alone.

The projected drilling boom will require sharply-increased production of drilling equipment, vehicles, and materials of all kinds — most of which are now in short supply.

Will Need Many New Pipelines

To transport the steadily-rising gas output, Russia expects to build 35 to 40,000 km of new gas pipeline between now and 1965. Of this, 25 to 30,000 km will be trunk lines and 10,000 km will be lateral lines to cities and towns.

Scope of the USSR's pipelining program is underscored by the fact that Russia now has only about 10,000 km of long-distance gas lines, more than half of it completed in the last three years.

В диспетчерской Московского управления газопроводов. У пульта связи главный диспетчер Л. Генкина (сидит) и сменный диспетчер В. Светцова.
Фото Д. Минскера.

Women dispatchers in the control room of the Moscow Gas Pipeline Administration. Chief dispatcher L. Genkina (seated) and shift dispatcher V. Svetsova (standing).

New Soviet plans call for construction of a mutually-linked transmission system connecting the most important economic regions of European Russia, the Urals, and Central Asia.

Main directions of gas movement will be: From the Stavropol and Krasnodar fields northward to the central economic region around Moscow and on to Leningrad; from the eastern Ukrainian fields around Shebelinka northward to Kharkov, Kursk, Orel, Bryansk, Pskov, and Leningrad and southward to Zaporozhe, Dnepropetrovsk, Nikolaev, Kherson, and Odessa; from the western Ukrainian fields near Dashava northeastward to Kiev, Bryansk, and Moscow and northward to Lvov, Minsk, Leningrad, Riga, and other points in the Baltic Sea area; from the Stalingrad and Saratov fields northward to Gorki, Yaroslavl, etc., and eastward to the Urals; and from the lower Ob River, Komi Republic (Ukhta) and Berezovo (Tyumen) fields southward to such Ural industrial centers as Berezniki, Solikamsk, Perm (formerly Molotov), and Sverdlovsk.

Gas from the Azerbaijan fields at Karadag near Baku will be transmitted westward, through the Caucasus Mountains to Kirovabad, Akstafa, Tbilisi, capital of Georgia, and Erevan, capital of Armenia. Bukhara gas will go eastward to Samarkand, then north to Tashkent and other Central Asian cities. Shale gas will continue to be piped from Khotla-Jarve, Estonia, to Tallinn and Leningrad.

Construction is already underway on the line that will carry Stavropol gas from Serpukhov, south of Moscow, to Leningrad via Kalinin. Work on the Dzharkak-Bukhara-Tashkent line also is in progress.

The State Planning Committee has ordered new pipeline construction work to "proceed on a high technical level, using the most advanced types of equipment and communications, automatic and remote control devices, and centrifugal compressors driven by 5 to 12,000-kw gas turbines. Reciprocating compressors rated at 1000 hp are now most widely used on Soviet long distance gas pipelines.

Until recently, the Russians used small-diameter 300 to 500 mm (12 to 20-in.) pipe in building long-distance gas transmission lines. Movement through these lines, they admit, "did not exceed several hundred million cubic meters of gas annually."

Future Emphasis On Large Pipe

Future emphasis will be on large-diameter lines employing high-capacity centrifugal compressors run by gas turbines as well as gas engine compressors larger than any now being built in the USSR. Productivity of new turbine-driven centrifugal compressors being readied for manufacture at the Lenin factory in Leningrad will be "about 25 times greater than the pro-

TABLE 1. Change in Character of Russian Fuel Production.

Type of fuel	Percentage of total output in equivalent units						
	1940	1955	1957	1958	1959	1960	1965
Coal	61.0	64.8	61.9	59.8	57.6	55.1	44.0
Oil	19.0	22.4	25.3	26.1	26.6	27.1	32.3
Gas*	1.7	2.4	4.2	5.9	8.1	10.1	17.2
Peat	5.5	4.4	3.7	3.7	3.5	3.8	3.1
Shale	0.3	0.6	0.6	0.6	0.5	0.5	0.5
Wood	12.5	5.4	4.3	3.9	3.7	3.4	2.7

*Includes natural, casinghead, and manufactured gas.

†1 meter equals 3.28 ft.

TABLE 2. Russian Gas Production.

Year	Millions of cubic meters
1928	331
1932	1,089
1937	2,317
1940	3,392
1950	6,181
1955	10,356
1956	13,678
1957	20,200
1958*	30,700
1967—72*	270,000-300,000

*Official plan.

ductivity of present gas engine compressors being built at a Gorki plant."

Presently-lagging compressor station construction will be accelerated, especially on the Stavropol-Moscow line. Russia hopes to be producing 100 to 120 of the big new compressor units annually within the next two to three years.

Soviet officials also show serious concern over the "unsatisfactory" production of gas pipeline valves.

The Myshegsky factory, they explain, "has not fulfilled its task of producing valves with automatic and remote control. Meanwhile, the gas industry in 1958 alone will need 3000-3500 valves, or almost twice the 1957 output. At the same time we must quickly begin making valves for gas pipelines of 800-1000 mm (31-39-in.) diam."

The State Planning Committee believes the most important problem facing Russian gas pipeline builders is to procure enough pipe 1000-mm (39-in.) in diam and larger. Large-diameter pipe, the committee points out, would permit a substantial savings in scarce steel in relation to a line's capacity.

Russian economists are urging that sheet steel used for large-diameter pipe be reduced to 6 to 8 mm (2.34 to 3.12 in.) thickness. At present, the newspaper *Promyshlenno-Ekonomicheskaya Gazeta (Industrial-Economic Gazette)* complains, "25 percent of the metal used in building Russian gas pipelines is wasted due to excessive thickness of pipe walls."

Failure to make full use of the pipelines already built and in service presents another difficult problem for the Soviet gas industry.

In large cities such as Rostov, Voroshilovgrad, Sumgait, Dnepropetrovsk, and Kharkov, many factories, public buildings, and homes were not equipped to use natural gas when it became available. The Minnibaevo-Kazan, Anastasievo-Novorossiisk, Karadag-Sumgait, Shebelinka-Dnepropetrovsk, and other pipelines are transmitting oil well (casinghead) gas at far less than capacity both because gathering facilities are incomplete and because consumers aren't ready for the gas that can be delivered.

"Besides that," the magazine *Planovoye Khoziaistvo* reports, "construction of compressor stations on several of the largest gas pipelines is lagging badly. This has significantly reduced the utilization of the lines during their first years of operation.

"For example, on the first Stavropol-Moscow pipeline only one compressor station is operating (as of November 1957), although the line was officially completed in 1956. Eight more compressor stations must be built before the 807-mile line can transmit at full capacity."

Leading Soviet newspapers have voiced harsh criticism of administrative inefficiency in carrying out directives for pipeline construction. Delays in delivering large-diameter pipe have been the biggest bottleneck in the past, but failure to get into mass production on bigger equipment suitable for laying larger pipe is regarded as a major threat to future construction goals.

Pipe Production Lagging

Although the first Stavropol-Moscow pipeline was placed in service a year ahead of schedule, work would have progressed even faster except for 720-mm (28-in.) pipe shortages. Last summer, the newspaper *Izvestia* asserts, construction crews on the second Stavropol-Moscow link were idled almost two months by insufficient pipe.

Russia hopes to double large-diameter pipe production in 1958-1959 and to boost output far higher during the 1960's as new pipe mills are completed. Preparations for building the additional mills are lagging, however.

At present, production of large-diameter pipe is concentrated at the Chelyabinsk plant in the eastern Urals. This mill must get its sheet steel from suppliers in the Ukraine and then ship the finished pipe back across the Urals to European Russia.

The Chelyabinsk plant was slated to begin deliveries of 820-mm (32-in.) pipe for the second Stavropol-Moscow line last year, but failed to meet schedules for it as well as for new thin-wall pipe, for coated pipe, and for longer pipe lengths. Furthermore, failure to give priority to pipe needed for gathering lines to new gas wells near Stavropol has prevented the first (southern) section of the second Stavropol-Moscow line from going into service.

Although work on the second main Stavropol-Moscow line is almost entirely mechanized, much of the labor is still being done by hand methods on the small-diameter branch lines into cities, towns, and industrial plants.

The newspaper *Sovetskaya Rossiya* says there are no cleaning and coating machines for the smaller pipe. "Workers are cleaning the pipe surfaces with bricks and coating it by primitive methods. This is intolerable.

"A great deal of labor is spent in cleaning and coating the pipe under field conditions, but this work usually can't be done when it is raining, snowing, or foggy. It would be better if pipe coating were done at the pipe mills, as is the case in Czechoslovakia."

Cooperation Lacking

Work on the second Stavropol-Moscow line is being done by several construction organizations. "As a result," *"Sovetskaya Rossiya* observes, "if even the smallest argument arises between the directors, the dispute must be sent to Moscow for settlement.

"Sometimes inter-departmental barriers cause great harm. One organization frequently has machinery standing idle which another organization lacks. Isn't it time to eliminate such aloofness and create one overall organization?

"Another thing. Any construction project usually begins with the building of roads and auxiliary installations. But, unfortunately, this rule is not being observed.

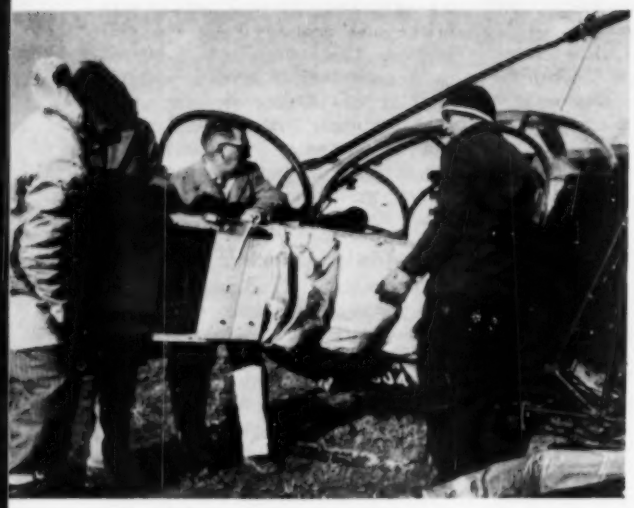
"The first Stavropol-Moscow main line has been in service for some time, but the communications still aren't finished. The same is true for many auxiliary services. The road to Stavropol producing wells isn't completed, and you can only get there by tractor in bad weather."

Izvestia emphasized that a large number of tractors, excavators, bulldozers, and pipelaying machines with extra-wide caterpillar treads for marshy ground are needed this year for work on the new Serpukhov-Leningrad and Dashava-Minsk pipelines. "More pipe, material, and personnel carriers, for use over difficult terrain are also required or work will stop during rainy and wintry weather."

Existing pipe coating, cleaning, and welding equipment is unsuitable for 820-mm (32-in.) pipe or larger and must be replaced. The 93-hp S-80 tractor, around which much of Russia's pipelaying machinery is built, lacks the power to handle either 720 or 820-mm pipe efficiently. But the bigger S-100, S-140, and S-250 tractors are still in the experimental stage.

Izvestia says that with 720-mm (28-in.) pipe, two pipelaying machines mounted on S-250 tractors could do the work of five pipelayers mounted on S-80s. "A bulldozer with turning blade mounted on a S-250 would do 20 to 30 times the backfilling work of existing bulldozers."

Izvestia called on the USSR's State Planning Committee to "consider these urgent needs of Soviet pipeline builders in allocating 1958 funds." ★ ★ ★



1 Uncrated microwave equipment is loaded into cab of jet helicopter. Doors were taken off to accommodate the equipment.

2 And away we go . . . crated in box, microwave gear heads for the rugged mountain country of New Mexico and a new home on a 9800 ft mountain peak.

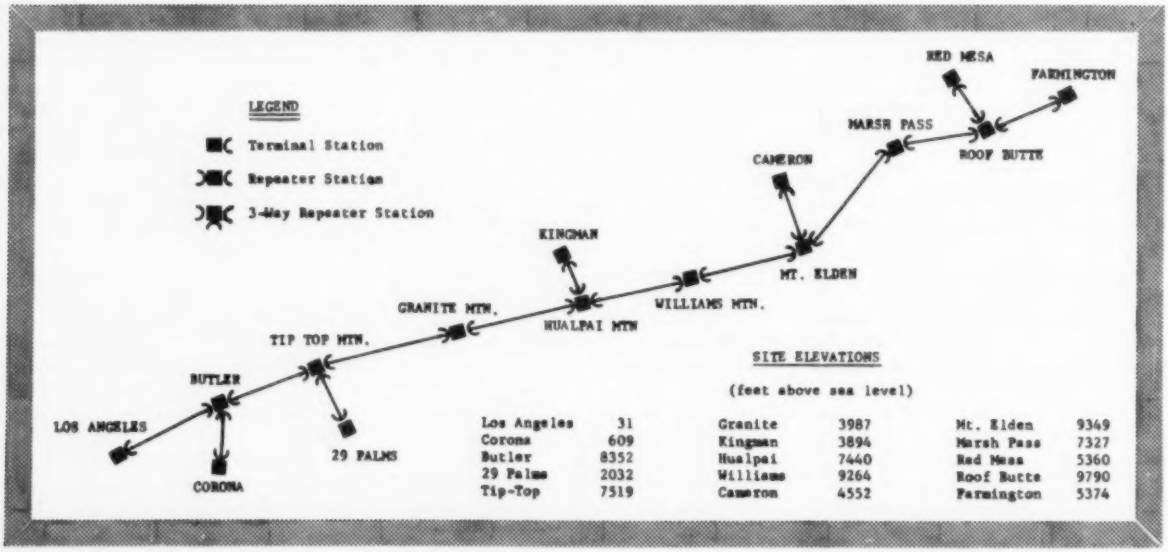
New jet whirlybird made
21 trips to deliver gear
Nearly two miles high for . . .

The microwave station that came by "airlift"

ATOP A 9800-ft peak in the heart of the Lukachukai mountains in northwestern New Mexico sits a unique pipeline microwave system, the result of an unprecedented airlift of electronic equipment by jet helicopter.

The microwave system, installed by General Electric's Communication Products Department for Four Corners Pipe Line Company helps control the movement of crude oil through the new line from Utah to California. Microwave equipment provides supervisory control and voice functions over a route of more than 850 miles.

Airlift of the communication devices was the civilian's first demonstration of Republic Aviation's new "Alouette" jet helicopter, built for commercial purposes. It previously had been employed only in military applications.



3 Enroute to Roof Butte, new jet helicopter and precious load looked like this from the ground.

Especially-designed for high altitudes, the aircraft lifted nearly three tons of microwave equipment in what is described as one of the most difficult flying areas in the United States.

Decision to fly the material to the mountain peak was reached by engineers when weather conditions made it virtually impossible to reach the top over rough, snow-clogged roads which extended only part way up the rocky mountainside.

GE field engineer Svend Nielsen theorized that carrying the equipment by helicopter would eliminate any possibility that the units would suffer damage in land transit up the rugged mountain.

Reliability in the system is a key feature in the pipeline's operational plans. Because of the terrain, necessity compelled Four Corners' microwave engineer Wells Garvin to do everything possible to make the system highly reliable and easily maintained once installed. The equipment was designed with extra dust-filtering equipment due to atmospheric conditions in the area and extra precautions were taken in relationship to temperature control and cooling.

The system is built so that maintenance would be necessary only at infrequent intervals. Protection of the system was an important factor, therefore, in the airlift decision.

As the airlift got underway, an atmosphere of drama surrounded the mission. A test run by pilot Thomas Mason, flying the 400-hp helicopter, revealed that the proposed landing field on the peak was not large enough to accommodate the 32-ft long aircraft.

Special federal permission had to be obtained to clear the site.

Equipped with a chain saw, personnel were landed on a lower slope of the mountain several hundred feet from the top. They trudged through snow the remainder of the distance to eliminate the timber obstructions.

Because of rough weather conditions, it was decided that no attempt would be made to over-extend the helicopter. Before the delicate operation was completed, 21 trips to the peak were necessary.

The mountain where the airlifted portion of the system has been installed — Roof Butte — is a vital part of the 850-mile microwave network. Not far away is Four Corners' Red Mesa station, terminal for the pipeline and initial station for oil that will course through the pipe from gathering points to the West Coast.

When the system is complete, it will involve a high degree of automation. The line will be on an unattended basis, making the supervisory control function extremely important in remote tank gaging. The pipeline route covers terrain ranging from 600 to 6000 ft above sea level and rapid control is needed to take care of changing surge conditions in the oil's flow through the pipe.

Engineered with a strong system gain, the microwave system makes possible several long paths in the Four Corners communication set-up. Three of these paths are more than 100 miles — or twice as long as hops usually found in pipeline and utility microwave plans. The communications system includes 100 percent RF and multiplex stand-by equipment.

VHF repeaters facilitate voice communication from the pipeline's office at Los Angeles to its facilities at Farmington, New Mexico, not far from the mountain location. Covering the entire pipeline right-of-way, the VHF portion of the network provides communication with mobile radios in management and supervisory cars.

Included in the communication plans are a dial-selective party-line telephone-type channel from Los Angeles to Farmington and a private channel. ★ ★ ★

4 Republic Aviation's "Alouette II" comes in for spot landing at site of new station on Roof Butte's flat top. Intricate equipment was unloaded and installed immediately in its racks inside the repeater station building.

How gas storage wells behave

C. J. Walker and H. N. Dunning
U. S. Bureau of Mines, Petroleum Experiment Station, Bartlesville, Oklahoma

Part 3

DEMAND FOR NATURAL gas for industrial and domestic uses has increased tremendously in recent years. Transmission lines capable of supplying the peak demands of industrial and domestic areas far removed from the natural sources of gas are not always economically feasible. An answer has been found in the use of depleted oil and gas reservoirs and water-bearing formations suitable for the storage of vast quantities of gas near the markets.

The number of storage reservoirs increased from 50, with an estimated capacity of 135 billion cu ft of gas in 11 states in 1944, to 188, with an estimated capacity of 3 trillion cu ft in 20 states in 1956.[1] In 1953, the American Gas Association, through the Underground Storage Committee and Deliverability Problems Subcommittee, began a cooperative project with the Bureau of Mines on the deliverability of gas wells in storage reservoirs.

The wells of five gas-storage reservoirs and one gas field have been tested in this deliverability study. Back-pressure tests were made during withdrawal and injection operations on all the gas-storage projects and during withdrawal operations on the gas field. The tests on two of the storage projects, Ulan in Oklahoma and Bridgeport in West Virginia, have been described recently.[2, 3] The conclusions based on these early studies were as follows:

(1). Composite back-pressure curves calculated from individual well curves plotted as straight lines on log-log paper. Therefore, generalizations may be made concerning the behavior of the reservoir and of the wells as a group.

(2). For gas-storage projects in shallow reservoirs, there was little advantage in making the extensive calculations required to correct the back-pressure curves to bottom-hole conditions. It was concluded that, for studies of wells in most storage projects, wellhead deliverability tests are more practicable than those based on bottom-hole conditions.

(3). A new measure of deliverability, called the "Q_{10}" value, was suggested as a replacement for the "open flow" and "C" values that have been used previously. The Q_{10} value is defined as the rate of flow of gas from a well when $(P_c^2 - P_w^2)$ or $(P_f^2 - P_s^2)$ in the back-pressure equation,[4] $Q = C(P_c^2 - P_w^2)^n$, is equal to 10,000. This value, unlike open flow and the C value, does not involve extended, and often unjustified, extrapolation of the back-pressure curve. Results of these tests and references to the literature showed that this level of pressure difference is generally near or within the range of back-pressure tests. Furthermore, the "Q_{10}" value results in conclusions regarding well deliverabilities in agreement with conclusions from the back-pressure curves.

These conclusions have been generally corroborated by recent studies of the four additional reservoirs.

Procedures

Tests conducted on the additional four reservoirs were of the same general types as those reported previously.[2,3] These studies consisted of the simultaneous testing of groups of wells wherever possible. Conventional back-pressure tests were conducted on groups of wells of the Osage storage project in Oklahoma and the South Bend storage project in Pennsylvania. Orifice runs at the wells permitted the measurement of rates and pressures at the wellheads during both injection and withdrawal tests.

The small Buffalo storage project in Kansas was subjected to conventional withdrawal and injection back-pressure tests, but flow rates were measured at the field meter run, as there were no well-orifice runs.

Three wells of the N. W. Mayflower gas field in Oklahoma were tested by both isochronal performance[5] and conventional back-pressure methods during withdrawal operations. These wells also were subjected to 24-hr tests during which changes in rates and pressures were recorded at frequent intervals.

Results and Discussion

Conventional back-pressure tests. The results of two series of tests made in April and December of 1955, at different reservoir pressures during withdrawal and injection operations, on six wells of the South Bend storage project, are summarized in Tables 1 and 2. Table 1 illustrates the range of "n" and "C" values of the individual wells and the "n" and "C" values of the com-

Table 1. Summary of "n" and "C"[a] Values[b] for Back-Pressure Curves of Six Wells and Composite Curves, Withdrawal, South Bend Gas-Storage Project.

	Range	Average	Composite
Wellhead, April 1955[c]			
n	0.502– 0.715	0.579	0.590
C	2,683–18,716	9,508	44,996
Bottom-hole, April 1955[c]			
n	0.500– 0.728	0.576	0.589
C	2,266–18,345	9,475	44,250
Wellhead, December 1955[d]			
n	0.556– 0.660	0.610	0.607
C	1,506–11,262	5,947	33,410
Bottom-hole, December 1955[d]			
n	0.556– 0.677	0.615	0.612
C	1,187–10,706	5,607	30,269

[a] Cubic feet per day when $(P_c^2 - P_w^2) = 1$.
[b] From back-pressure equation: $Q = C(P_c^2 - P_w^2)^n$.
[c] Shut-in pressure, 450 psia.
[d] Shut-in pressure, 670 psia.

*This is a continuation of the results of field tests on gas storage reservoirs reported in Parts 1 and 2 (*The Pipeline Engineer*, August and September 1957). It also is a summary of tests conducted on six reservoirs during the last five years.

Table 2. Summary of Results of Back-Pressure Tests on Wells of the South Bend Gas-Storage Project.[a]

Well	n		C[c]		Q_{10}[d]		Q_{100}[e]	
	Withdrawal	Injection	Withdrawal	Injection	Withdrawal	Injection	Withdrawal	Injection
			P_c ~ 450 psia[b]					
1	0.566	0.590	13,259	10,488	2.43	2.39	8.92	9.29
2	.502	.595	18,716	7,038	1.90	1.68	6.04	6.61
3	.613	.599	5,151	6,058	1.46	1.51	5.98	6.00
4	.715	.627	2,683	7,603	1.94	2.44	10.07	10.32
5	.508	.628	7,603	2,347	.82	.76	2.64	3.24
6	.568	.581	9,637	8,433	1.81	1.79	6.68	6.81
Average	0.579	0.603	9,508	6,993	1.73	1.76	6.72	7.05
Average X No. wells			57,048	41,95[c]	10.38	10.56	40.32	42.30
Composite	.590	.602	44,996	41,307	10.34	10.57	40.27	42.27
			P_c ~ 670 psia[b]					
1	0.583	0.764	11,262	1,354	2.41	1.54	9.22	8.94
2	.660	.642	1,814	2,291	.79	.85	3.62	3.73
3	.588	.759	6,252	813	1.40	.88	5.43	5.06
4	.660	.715	4,335	2,566	2.16	1.85	9.85	9.61
5	.611	.829	1,506	116	.42	.24	1.72	1.61
6	.556	.682	10,512	2,321	1.77	1.24	6.35	5.95
Average	0.610	0.732	5,947	1,577	1.49	1.10	6.03	5.82
Average X No. wells			35,682	9,462	8.94	6.60	36.18	34.92
Composite	.607	.723	33,410	8,457	8.94	6.60	36.17	34.89

[a] Wells were tested as a group during injection and withdrawal operations. Results are based on back-pressure equation: $Q = C(P_c^2 - P_w^2)^n$.
[b] Shut-in wellhead pressure.
[c] Cubic feet per day when $(P_c^2 - P_w^2) = 1$.
[d] Million cubic feet per day when $(P_c^2 - P_w^2)$ or $(P_w^2 - P_c^2) = 10{,}000$.
[e] Million cubic feet per day when $(P_c^2 - P_w^2)$ or $(P_w^2 - P_c^2) = 100{,}000$.

posite curves at wellhead and bottom-hole conditions. Individual values of well-behavior parameters during injection and withdrawal operations are summarized in Table 2.

The "n" and "C" values were calculated directly from the data by the non-graphical method described recently.[6] The composite curves were obtained by plotting the points determined by adding the separate Q values of the several well curves at selected differences in squared pressures.

Back-pressure curves of the wells of the South Bend project together with the composite curve are displayed in Fig. 1. The ranges in "n" and "C" values for the South Bend project are quite similar to those of the Ulan and Bridgeport projects previously discussed.[2, 3]

Fig. 2 compares the composite curves obtained at wellhead and bottom-hole conditions at different reservoir pressures of the South Bend project. Little difference is indicated in deliverability at wellhead or bottom-hole conditions. In fact, the difference is less than that between the results at different reservoir pressures. This demonstrates again that for shallow and low-pressure reservoirs such as this (1700 ft, 670 psia), deliverability can be based on wellhead pressures.

Results of conventional back-pressure tests on seven wells of the Osage gas-storage project, Oklahoma, are summarized in Table 3. Wells of the storage project have considerably higher "n" values and values of deliverability than do those of the South Bend, Ulan, and Bridgeport projects. This difference of the Osage project from the three other large projects tested is especially apparent in Fig. 3 in which the composite curves of the four projects are compared. It appears that the generally high "n" and deliverability values of this project are a reflection of the high permeability of the formation.

Another difference of the results of tests on the Osage project from those of tests on the South Bend, Bridgeport, and Ulan projects is observed in comparing "n" values of back-pressure curves determined during injection and withdrawal operations. Unlike the back-pressure curves for the three other projects, those of the Osage project show no general displacement of the injection type from the withdrawal.

The results of conventional back-pressure tests on 2 of 20 wells and the Buffalo storage project as a whole are summarized in Table 4.

As observed in tests on the South Bend storage project discussed above and on the Ulan and Bridgeport storage projects,[2, 3] the total-field back-pressure curves determined during injection are displaced toward the pressure axis compared to the corresponding withdrawal tests. That is, the C value is lower and the slope greater during withdrawal than injection. However, the inverse relationship is observed for the two individual wells of this project that were tested. It must be inferred that the majority of wells in the field, if all are of approximately equal capacity, have a different trend of "n" and "C" values from those of

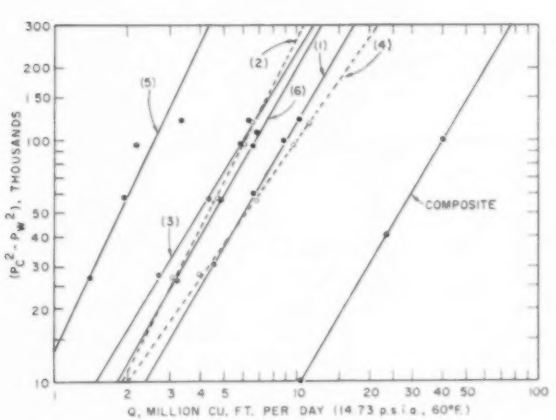


Figure 1.–Conventional back-pressure curves and composite curve for South Bend project. (Wellhead conditions, April 1955, average shut-in pressure: 450 p.s.i.a.)

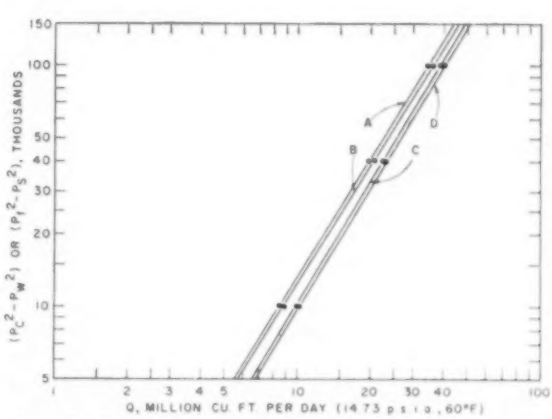


Figure 2.–Composite curves determined at bottom-hole and wellhead conditions from conventional back-pressure curves of wells in the South Bend project. (1955, 1956)

Curve A: 1956 } P_c ~ 670 p.s.i.a. { Bottom-hole / Wellhead
Curve B: 1956 }
Curve C: 1955 } P_c ~ 450 p.s.i.a. { Bottom-hole / Wellhead
Curve D: 1955 }

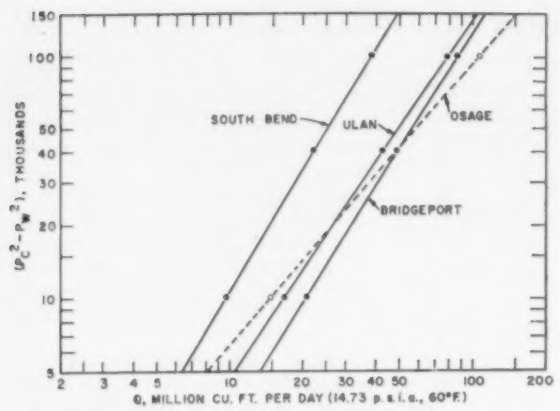


Figure 3.-Comparison of composite back-pressure curves for gas-storage projects. (Well conditions, withdrawal.)

South Bend project, 6 wells, formation pressure ~450 and 670 p.s.i.a.
Ulan project, 8 wells, formation pressure ~300 and 400 p.s.i.a.
Osage project, 7 wells, formation pressure ~350 p.s.i.a.
Bridgeport project, 7 wells, formation pressure ~150 and 500 p.s.i.a.

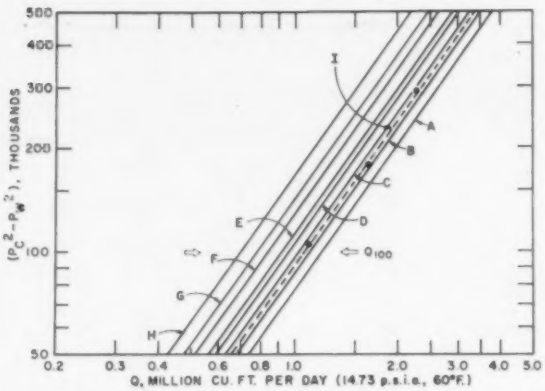


Figure 5.-Estimated isochronal performance pressure curves for Well M-1.

2-hour isochronal curve. (I)
Estimated curves using data from 24-hour flow test. (A-H)

FLOW PTS.	TIME, HOURS
A	0.5
B	1.0
C	2.0
D	3.0
E	4.0
F	8.0
G	12.0
H	24.0

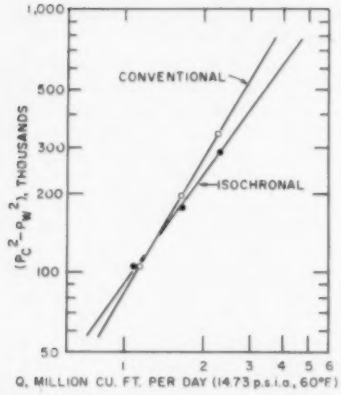


Figure 4.-Comparison of conventional back-pressure and isochronal performance curves for Well M-1.

the two wells tested. However, the "Q_{10}" values for the field and for the two wells are relatively constant during injection and withdrawal.

These results indicate that, whereas the conclusions relating to injection and withdrawal curves drawn from the earlier tests [2, 3] often may prove valid, back-pressure curves obtained during injection operations cannot necessarily be expected to be displaced toward the pressure axis from those determined during withdrawal operations nor do they necessarily have larger "n" values.

Special Back-Pressure Tests

The performance characteristics of two of the three wells in the N. W. Mayflower gas field were determined by the isochronal performance and conventional back-pressure methods.

Table 3. Summary of Results of Back-Pressure Tests on Wells of the Osage Gas-Storage Project.[a]

Well	n		C[b]		Q_{10}[c]	
	Withdrawal	Injection	Withdrawal	Injection	Withdrawal	Injection
1	0.878	0.835	1,351	2,054	4.39	4.49
2	.866	.897	969	732	2.83	2.84
3	.893	.908	571	594	2.17	2.54
4	.858	.768	163	308	.44	.36
5	.892	.753	178	646	.69	.66
6	.848	.774	1,546	3,381	3.80	4.22
7	.813	.918	191	50	.34	.24
1[d]	.865	.830	1,564	2,183	4.52	4.53
6[d]	.844	.860	1,740	1,330	4.12	3.67
Average[e]	0.864	0.836	710	1,109	2.09	2.19
Average X No. wells[e]			4,970	7,763	14.63	15.33
Composite[f]	.867	.841	4,969	6,617	14.63	15.35

[a] Obtained by conventional (flow-after-flow) back-pressure tests on a group of seven wells and two individual wells during withdrawal and injection operations at a reservoir pressure of approximately 350 psia wellhead conditions. Based on back-pressure equation: $Q = C(P_c^2 - P_w^2)^n$.
[b] Cubic feet per day when $(P_c^2 - P_w^2) = 1$, (14.73 psia, 60 F.).
[c] Million cubic feet per day when $(P_c^2 - P_w^2)$ or $(P_w^2 - P_c^2) = 10{,}000$.
[d] Individual well test.
[e] Refers to group test.
[f] Calculated from group test.

Table 4. Summary of Results of Back-Pressure Tests on the Buffalo Gas-Storage Project.[a]

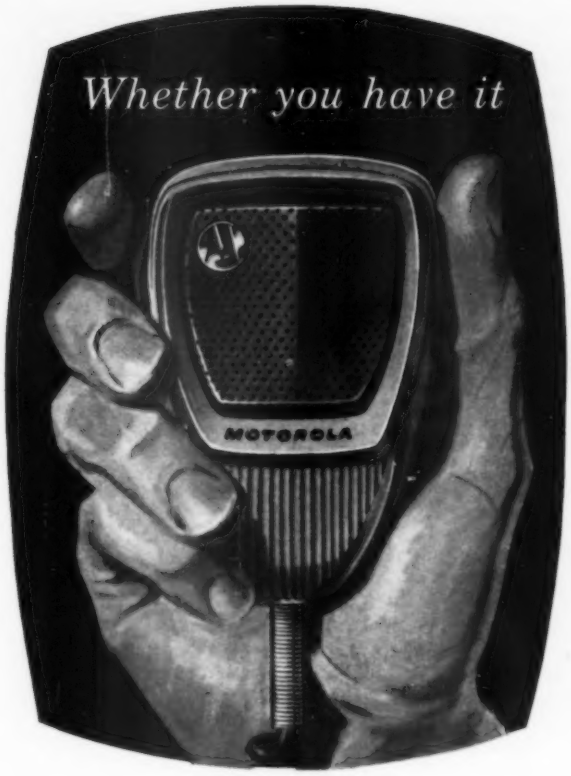
Well	n		C[b]		Q_{10}[c]	
	Withdrawal	Injection	Withdrawal	Injection	Withdrawal	Injection
1	0.915	0.853	405	663	1.86	1.72
2	.778	.722	295	471	.38	.36
Total project	.690	.719	19,442	16,941	11.20	12.42

[a] During withdrawal and injection operations at reservoir shut-in pressures of 94 psia and 84 psia, respectively, wellhead conditions. Based on back-pressure equation: $Q = (P_c^2 - P_w^2)^n$.
[b] Cubic feet per day when $(P_c^2 - P_w^2) = 1$, (14.73 psia and 60 F.).
[c] Million cubic feet per day when $(P_c^2 - P_w^2)$ or $(P_w^2 - P_c^2) = 10{,}000$.

The results are summarized in Table 5.

The third well produced condensate in slugs and therefore did not give consistent results. The curves of the tests conducted on well M-1 are shown in Fig. 4.

The "n" values obtained from the isochronal performance tests are larger than those determined by conventional back-pressure tests for both wells. This observation is in agreement with those of Cullender.[5] As indicated by Cullender, the isochronal method results in more accurate evaluation of slowly stabilizing wells than does the conventional method.



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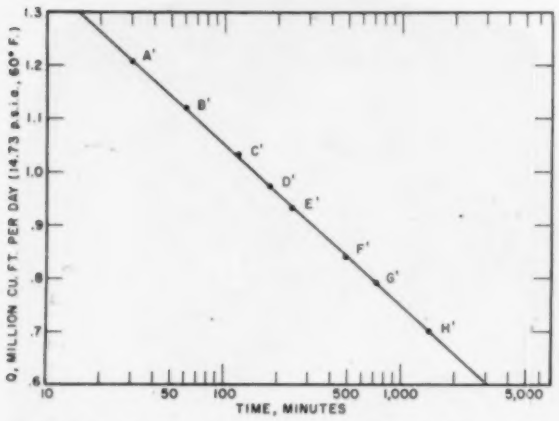

Figure 6 – Q_{100} values as a function of time, well M-1.

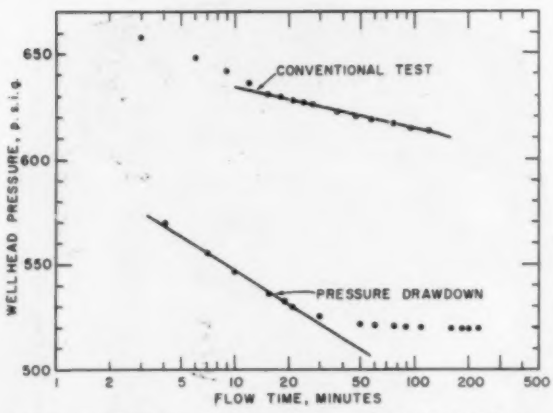

Figure 7.– Pressure drawdown data for Well SB-2 during conventional back-pressure test and regular drawdown test.

	CONVENTIONAL	DRAWDOWN
m	−20.0	−54.0 p.s.i./cycle
Q	2,590	5,280 Mcf/day
P_c	666.0	658.2 p.s.i.g.
K	72	56 md.
S.E.	-3.4	-2.8

Results obtained in tests of wells that stabilize rapidly are less dependent on the method used.[2, 3] With wells that stabilize slowly, if at all, the conventional back-pressure test should have its greatest accuracy at the initial test point. Indeed, the initial point of the conventional test is an isochronal point, and hence should fall on the isochronal curve within experimental error. Later conventional test points tend to fall increasingly farther from the isochronal curve. Consequently, errors in open flow values and "C" values determined by extrapolation of conventional back-pressure tests of wells in formations of low permeability increase as a function of extrapolation. This trend is shown in Table 5.

The "Q_{10}" values obtained by the conventional method are larger than those obtained by the isochronal method while the "Q_{200}" values are the reverse. However, in tests of wells with more rapid stabilization, Walker and associates [2, 3] found good agreement in the "Q_{10}" values observed by the two methods. These results emphasize the desirability of rating wells at a level of $(P_c^2 - P_w^2)$ near that at which they were tested. The resulting accuracy also indicates the value of the isochronal performance method for slowly stabilizing wells and as a research tool. In many fields, however, the conventional back-pressure test gives reliable predictions of well behavior and may be preferred because of its less time-consuming characteristics.

It has been shown [5, 2, 3] that the curves representing isochronal performance tests usually form a family — the individual curves of which have the same slope and are displaced toward the pressure axis with increased duration. That is, the characteristic slope, developed under brief flow conditions, is applicable to flow conditions of extended periods. Therefore, the combination of a multi-point flow test of short periods and a single-point, extended period test should allow the best approximation of well behavior under operating conditions.

For routine test purposes, and for wells of reasonable stabilization periods, the characteristic slope may be determined by the conventional back-pressure method. This method has been selected by the Industry Committee of the Kansas Corporation Commission.[7]

Isochronal performance tests to establish the characteristic "n" value would appear advisable for intensive studies of wells in formations of low permeability. The use of this combination of tests is illustrated in Fig. 5. An isochronal performance test of 2-hr periods (curve I) was made. Then, the well was shut in and allowed to return to original conditions. Finally, a 24-hr flow test was made during which wellhead pressures and corresponding rates of flow were recorded at frequent intervals. The data from the 24-hr test were used to plot points A through H. Because each of these points is essentially an "isochronal" point, it may be used to determine the location of a line having the same slope as the isochronal curve, and passing through the point characteristic of a given period. This family of lines then may be used to approximate the deliverability of the well at any given difference of pressures squared ($\triangle P^2$) and at any period of flow less than that of the extended-flow test.

Values of deliverability at given differences in pressures squared (Q_{10}, Q_{100}) may be read directly from such figures or calculated from the the back-pressure equation. The simplified form of the equation for curve A is:

$$\log Q_{100} = \log Q_A - n\,(\log \triangle P_A^2 - 5).$$

or more generally:

Table 5. Comparison of Isochronal Performance with Conventional Back-Pressure Curves for Two Wells of the N. W. Mayflower Gas Field,[a] 2-hr Flow Periods.

	Isochronal				Conventional back-pressure			
Well	n	C[b]	Q_{10}[c]	Q_{200}[d]	n	C	Q_{10}	Q_{200}
1	0.717	280	0.21	1.76	0.595	1,161	0.28	1.66
2	.717	193	.14	1.23	.588	889	.20	1.17

[a] Based on back-pressure equation: $Q = (P_c^2 - P_w^2)^n$, wellhead conditions.
[b] Cubic feet per day when $(P_c^2 - P_w^2) = 1$.
[c] Million cubic feet per day when $(P_c^2 - P_w^2) = 10{,}000$.
[d] Million cubic feet per day when $(P_c^2 - P_w^2) = 200{,}000$.

Table 6. Pressure-Drawdown Data for Well SB-2 During Back-Pressure Test and Regular Drawdown Test.

	Conventional	Drawdown
m, psi/cycle	−20.0	−54.0
Q, Mcf/day	2,590	5,280
P, psig	666.0	658.2
K, md	72	56
S.E.	−3.4	−2.8

$\log Q_{100} = \log Q_t - n (\log \triangle P_t^2 - 5)$. where Q_t and $\triangle P_t^2$ refer to the flow rate and the difference in squared pressures of a given point.

If the rates obtained by selecting some difference in squared pressures ("Q_{100}" as indicated by arrows in Fig 5) are plotted on semi-logarithmic graph paper with the flow period on the logarithmic scale, a straight-line relationship often is obtained, as illustrated in Fig. 6. Points A′ through H′ (Fig. 6) represent the "Q_{100}" values of the isochronal curves drawn through flow points A through H (Fig. 5). This relationship is consistent with the straight-line relationship of "C" versus time with time on the logarithmic scale of semi-logarithmic graph paper as reported by Cullender.[5] When this relationship is observed, it can be expected to hold only until stabilization is reached. After stabilization the "Q_{100}" values obtained by extrapolating the straight line would be smaller than the actual well deliverability at that difference in squared pressures. However, the relationship is useful in determining the lower limit of deliverability.

If the extended-period flow test is continued until stabilization of pressures and flow rates are sensibly attained, the data establish a point through which a line of predetermined slope is drawn. This curve represents the stabilized, isochronal performance of the well and provides the most reasonable approximation of deliverability under normal, extended-withdrawal periods.

The first flow period of conventional back-pressure tests or any flow period of isochronal performance tests provide an opportunity for obtaining data useful in pressure-drawdown calculations. The only additional observations required are values of pressure and flow rate as a function of time during the flow period. Then the pressure-drawndown curve is obtained by plotting wellhead pressures on a linear scale and flowing time on a logarithmic scale.[6]

The equations used in calculating well characteristics involve some factors that usually are not known with any degree of certainty, for example, the effective well-bore radius, effective porosity, and effective formation thickness. Their use also requires somewhat subjective evaluation of the pressure-drawdown curve. However, such calculations provide approximate values of effective permeabilities and "skin effects." The skin effect is used to describe the relationship between the permeability of the formation immediately around the well bore and that of the formation. A positive skin effect indicates a zone of reduced permeability around the well bore; a negative skin effect indicates a zone of improved permeability near the well bore.

The comparison of pressure-drawdown calculations on data from the first period of a conventional back-pressure test and from a pressure-drawdown test is presented in Fig. 7 and Table 6.

Although the tests were conducted at considerably different rates of flow, the calculated values of permeability and skin effect are in good agreement.

Pressure drawdown tests were made on five of the seven wells tested in the Bridgeport storage project during the back-pressure tests of 1956. These were obtained during the first flow period when the shut-in pressure was approximately 500 psia. Effective permeability values ranged from 164 md for well B-7, which had the smallest deliverability ($Q_{10} = 0.75$ million cu ft per day) to 1200 md for well B-2, which had the highest deliverability. The values of skin effect ranged from −2.2 to +0.1. Values of effective permeability increased as the deliverability increased, probably because the skin effects varied over a rather narrow range.

Conclusions

Original conclusions[2, 3] based on tests of two gas-storage projects have been corroborated, with minor amendments, by recent tests on three gas-storage projects and a gas field.

(1) Composite back-pressure curves calculated from individual well curves plotted as straight lines on log-log paper. Therefore, generalizations may be made of the behavior of the reservoir and of the wells as a group.

(2) These generalizations show that, for gas-storage projects in shallow reservoirs, there is little advantage in making the extensive calculations required to correct the back-pressure curves to bottom-hole conditions. It is concluded that for most purposes wellhead deliverability tests are more practicable than those based on bottom-hole conditions.

(3) New measures of deliverability, called the "Q_{10}" or "Q_{100}" values, are suggested as replacements for the "open flow" and "C" values that have been used previously.

The "Q_{10}" or "Q_{100}" values are defined as the rates of flow of gas from a well when $(P_c^2 - P_w^2)$ or $(P_f^2 - P_s^2)$ in the back-pressure equation, $Q = C (P_c^2 - P_w^2)$, is equal to 10,000 or 100,000, respectively. These values, unlike open flow and the "C" value, do not involve extended and often unjustified extrapolation of the back-pressure curve.

Results of these tests and reference to the literature show that these levels of pressure differences are generally near or within the range of back-pressure tests. Furthermore, the "Q_{10}" or "Q_{100}" values result in conclusions regarding well deliverabilities in agreement with conclusions from visual reference to the back-pressure curve.

(4) The back-pressure curves obtained during injection cannot necessarily be expected to be displaced toward the pressure axis nor necessarily to have larger "n" values than corresponding curves obtained during withdrawal, although this behavior was observed in four out of five reservoirs tested.

Because the demand for increased storage capacity has necessitated the use of natural formations with permeabilities lower than those used heretofore, a means of estimating the deliverability of wells in such formations has become desirable. The use of an isochronal performance test and an extended-flow test to obtain a family of isochronal curves for various flow periods merits the consideration of those concerned with such gas-storage projects.

Acknowledgment

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PIPELINE WELDING

Part 3 — Standards of Acceptability

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BECAUSE a pipe weld may contain errors or defects, it is necessary to have a code or standard of acceptability to define the allowable limits of these defects for any given service or use to which the weld may be subjected.

A standard or code must insure an adequate margin of safety and dependability of service, and, at the same time, take into account economic factors that are pertinent to the design. For example, welds that are to be subjected to fatigue or cyclic stress in service would require a more rigid limitation of defects than welds that will be subjected to static stress only. **The more rigid the limitation of defect the higher the cost of producing the weld.**

It is logical that if an adequate degree of safety and dependability can be attained in a weld for static stress service with a less severe limitation of defect than that for the cyclic stress service, it would be economically wasteful to prescribe the same standard for both welds.

The question might now arise as to how are all of these things evaluated when the standard or code is written. Actually, a standard is based on a correlation of facts made available through extensive research and testing programs and through actual experience with the problem at hand. Welding standards of acceptability have evolved in this manner, and nearly all applicable codes for pipe welding are identical in most respects.

When performing work that is within the jurisdiction of a given code for construction, the designer must write contract or construction specifications that are in accordance with the requirements of the applicable code. Code requirements necessarily are general in many respects, but usually obligate the user to write detailed specifications in order to be in compliance with the code.

This is a reasonable method of obtaining the desired end result, because the information as to details of materials, design, service, etc., usually is available only to the designer.

Thus, welding specifications for a given job are written in compliance with all requirements of the prime code and will include any additional requirements that may be necessary to achieve the adequate margin of safety and dependability intended by the prime code. The welding specification will include requirements for preheat, stress relief, direction of welding, procedure qualification, welder qualification, etc.

PREHEAT

Preheat requirement for welding is a subject of much controversy and discussion. Use of preheat usually is opposed because of its cost. There are times, however, when preheat is necessary to insure good weld performance, and in this case economic considerations will be secondary. A situation could arise where a satisfactory weld could not be made without preheat. Suppose, for instance, two pieces of pipe are welded together using a qualified welding procedure and the completed weld is found to contain cracks, and using the same welding procedure with the addition of preheat, it is found that a crack-free weld can be produced on the same two pieces of pipe. Obviously, the cost of preheating cannot be considered objectionable, because without it a satisfactory weld cannot be produced at all. Unfortunately, the problem is not always as clearly defined as this.

In order to decide when preheat is necessary it would be useful to have some knowledge of what it actually does to the weld. When the weld is being made, the molten metal will be at temperatures in excess of 2000 F. During the cooling process, the metal will undergo many metallurgical changes. The final microstructure, constituents, grain size, hardness, etc., depends primarily on the **rate of cooling**.

Preheating will reduce the cooling rate of the weld, especially in the low temperature range below 400 F. To see why this reduced cooling rate is beneficial to the weld, it will be helpful to examine briefly the present day theories on causes and curves of microcracking. A theory on the effects of preheating has recently been presented by De Garmo, and appears to have a great deal of merit.

The theory essentially proposes that the primary benefit that is to be derived from preheating is the prevention of microcracking and/or under bead cracking. It has been established that for microcracking to occur both retained anstenite and hydrogen must be present as the weld cools. The elimination of either the retained anstenite or the hydrogen should therefore prevent microcracking. This has been demonstrated by the elimination of hydrogen in low hydrogen type electrodes. Unfortunately, this type of electrode is not yet satisfactory for production welding of downhill stringer beads on pipe.

Turning back to preheat, the question is what effect will it have on these two factors: (1) Actually the reduced cooling rate caused by preheating promotes the elimination of the retained anstenite and, according to De Garmo's theory, this is sufficient to prevent microcracks. Recognizing now that the primary purpose in using preheat is to prevent microcracking or underbead cracking, and that this can be accomplished by slowing down the cooling rate of the weld, the next fact is (2) When should preheat be used in pipe welding?

First of all, some steels are more crack sensitive than

other. Extensive tests have indicated that when the carbon equivalent (carbon equivalent $= C + \frac{Mn}{4}$)of a steel exceeds 0.58 that the steel tends to be crack sensitive. This means that when crack sensitive steels are welded at normal ambient temperatures (60 to 90 F) without preheat they are very susceptible to microcracks and underbead cracks.

Material specifications for line pipe allow carbon equivalent to be as high as 0.70, but fortunately, most pipe does not exceed 0.58, and can be welded in normal weather without preheat. However, the ambient temperature effect on the weld cooling rate may be the critical factor. The lower the ambient temperature, the higher the weld cooling rate.

Wall thickness will also affect the cooling rate, with heavier wall thickness causing higher cooling rates. The effect of diameter would be such that smaller diameters for any given wall thickness, carbon equivalent, and ambient temperature conditions, would have less tendency to require preheat.

We can now see the factors to be considered when determining preheat requirements are carbon equivalent of the pipe, ambient temperatures and wall thickness and diameter.

Many varied combinations of conditions could present themselves with regard to these factors. For example, the carbon equivalent could be high enough to require preheat even when ambient temperatures are 90 to 100 F.

Many times the carbon equivalent will be in a range that is weldable say for 50 F ambient temperatures and above, but requires preheat for ambient temperatures below 50 F. It is possible that a given material is weldable without preheat when it is used in small diameter light wall pipe, but is not weldable without preheat when it is used in large diameter heavy wall pipe. Obviously, deciding where and when to use preheat is not a simple task.

It would not be sensible economically to require preheat on all welds. Therefore, all of the many factors mentioned must be observed and considered prior to the start of a job and continuously as the job progresses. Chemical analysis of each heat of steel as supplied by the pipe manufacturer will provide information on carbon equivalents. High carbon equivalents should alert the welding engineer to the possibility of preheat being required on that pipe.

Since underbead cracks and microcracks are the defects that are to be eliminated by preheating, it is usually necessary to run physical tests on sample welds to detect the presence of such cracks when welding is being done under questionable circumstances. For example, as a job progresses, ambient temperatures may be getting continually lower and a preheat requirement may be needed. It is sometimes possible to detect this need by the appearance of excessive porosity in root beads when broken on a guided bend test. This porosity usually will appear before any show of cracks.

It is safe to say that when there is any doubt, the best course would be to use preheat, since the use of it cannot harm the weld, whereas the lack of it could.

Some specifications require that some of the coupons be subjected to tensile tests. However, unless these coupons can be machined to an accurate dimension and then pulled in an accurate tensile test machine, the results would be of questionable value. The guided bend and nick break test actually provide sufficient information for welder qualification purposes and can be done conveniently in the field.

Welding procedure for mild steel pipe is of the nature described in previous sections of the article. However, the testing of welders will also qualify the welding procedure. It is sometimes possible to determine preheat requirements during this testing. For example, if three out of four qualified welders showed excessive root bead porosity it would be worthwhile to retest them using preheat to see if this would eliminate the porosity.

Because all of the different conditions under which welding may be performed on a given job usually will not be encountered when qualifying the procedure, it may have to be changed as the job progresses. If it were possible, it would be useful to stimulate the worst conditions that might be encountered when qualifying the procedure. For example, if the lowest temperature, and highest chemistry pipe to be used on the job are used when making the procedure weld, a preheat requirement might be indicated. Of course, this would not mean that all welds would require preheat regardless of ambient temperature.

Obviously, all pipe is not going to have the same chemistry and ambient temperatures are going to vary. On the other hand, if the procedure is qualified on pipe that would not require preheat, this would not mean that all of the pipe made to this same specification would not require preheat. It should be evident that, in order to avoid the excess cost of using preheat when it is unnecessary, continual inspection of the welding is required and must be adequate to detect the need for preheat.

The test period will sometimes reveal such things as defective electrodes and defective welding machines. It should be noted that if several experienced welders fail to qualify, the procedure, material, electrodes, etc., should be examined closely to determine whether they are at fault.

Qualification of welders and welding procedures is a big step toward the accomplishment of acceptable welding on the job.

INSPECTION

Visual inspection is an indispensable tool for quality control of welding. The welding inspector is required to inspect all steps in the process, from the lineup to the completed weld. Good inspection can minimize the number of welds that might have to be cut out of the pipeline due to defects. For example, by observing lineups and making sure that proper space is used and hi-lo minimized, he makes it easier for the welder to produce a good stringer bead. The inspector should be certain that bevels are cleaned properly and that cleaning between weld passes is sufficient to minimize welding difficulties.

Also, the inspector must be familiar with applicable codes and specifications so that his judgment will insure that all substandard welds are removed from the pipeline. He should also be capable of detecting the source of welding problems that might arise on the job. A useful and necessary tool that is available to the welding inspector is X-ray. It is very successful in revealing stringer bead and internal defects in the finished weld.

By closely observing the type of defects and their frequency as detected by X-ray, it is usually possible to find the causes of these defects and eliminate them. For example, lack of penetration revealed by X-ray would indicate that lineups did not have proper root space and this could be corrected.

The use of X-ray will assist in determining whether or not preheat is necessary. Because of the many variables that affect preheat requirements, the inspector must continually watch for any indication that it may be needed at any given time. If X-ray should indicate excessive root bead porosity or the presence of base metal cracks, the inspector would be alerted to the possible need for preheat.

Well-performed welding inspection will assist the contractor in producing the high degree of quality of welding that is required by the applicable codes and specifications and will insure the safety and dependability of service that is required of a pipeline.

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● **C. P. Bartley & Son Pipe Line Construction, P. O. Box 616, Tioga, North Dakota.** Has 121 miles of 2 through 12-in. gas gathering extensions for *Signal Oil & Gas Company* in the Newton, North Dakota, area.

● **Oklahoma Pipe Line Constructors, P. O. Box 13227, Dallas 20, Texas.** Has 100 miles of 30-in. for *Creole Petroleum Corporation* between Temblador and Caripito, Venezuela; this is the company's first Venezuelan venture since 1944. Has 50 miles of 22-in. loops for *Portland Pipe Line Corporation* and *Montreal Pipe Line Company;* 39 miles in U. S. and 11 miles in Canada. Has 90 miles of 30-in. (known as Spread 14) for *Trans-Canada Pipe Lines, Ltd.*, from Toronto, Ontario, northward.

● **O. R. Burden Construction Corporation, Box 5216, Tulsa, Oklahoma.** Has 90 miles of 16-in. for *Humble Pipe Line Company* from Humble's Comyn station in Comanche County to its Hawley station in Jones County, Texas. Also has 76 miles of 20-in. for *Service Pipe Line Company* between Casper and Fort Laramie, Wyoming. Has 32.8 miles of 16-in. line to lay for *Panhandle Eastern Pipe Line Company* near Muncie, Indiana.

● **Macco Corporation, 14409 Paramount Blvd., Paramount, California.** Has 20 crews installing and replacing gas pipelines in Southern California area for *Southern California Gas Company* and *Southern Counties Gas Company*.

● **Midwestern Contractors, Inc., P. O. Box 587, Wheaton, Illinois.** Has 12 miles of 8-in. and 3 miles of 12-in. lines to lay in the Blue Island, Hammond, Whiting, Indiana area for *Clark Oil & Refining Company*.

● **Piggott Construction, Ltd, Calgary, Canada.** For *Interprovincial Pipe Line Company*, 82 miles of 24-in. loops in Alberta and Saskatchewan. For *Alberta Gas Trunk Line Company*, 145 miles of 24-in. from Pincher Creek field to Princess Junction, Alberta.

● **Mannix Company, Ltd., 737 Eighth Avenue West, Calgary, Alberta.** Has 93 miles of 30-in. for *Northern Ontario Pipe Line Crown Corporation* from a point 30 miles west of Hearst running to Kapuskassing, Ontario. Right of way clearing is being completed and pipe laying is to begin between May 15 and June 1. Has 50 miles additional work for *Pembina Pipeline Company*. This is a continuing contract with Pembina, of which 500 miles have now been completed since 1954. Has 45 miles of 16-in. gas transmission line from Pembina field to Calmar, Alberta, and 47 miles of 4 to 16-in. gas gathering lines in Pembina field for *Northwestern Utilities, Ltd.;* one 16-in. river crossing of the North Saskatchewan River is included in this project.

● **Canadian River Construction, 580 Hornby Street, Vancouver, British Columbia.** Has contract on Spread Y, containing 91.3 miles of 30-in. gas line from Longlac to MP 584.8 at the east bank of the Shekak River for *Northern Ontario Pipe Line Crown Corporation*.

● **Majestic Contractors Limited, 408 Royal Trust Building, Edmonton, Alberta.** Has contract for the 70.9 miles, 30-in. Spread X of *Northern Ontario Pipeline* between Beardmore to Longlac, Ontario. Has undetermined amount of gathering system for *Producers Pipeline Ltd.* in the Estavan, Saskatchewan, area. Has contract to lay city distribution system in Cooksville, Ontario, for *Consumer Gas Company*. Has city distribution system in Guelph, Ontario, for *Union Gas of Canada*. Has contract with *Trans-Canada Pipe Lines Ltd.* for 80 miles of 30-in. from Iroquois Falls to Kirkland Lake, Ontario.

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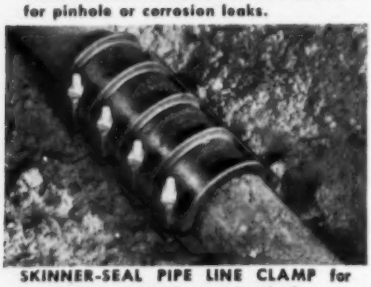

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Contractors

● **Western Pipe Line, Inc., 1011 San Jacinto, Austin 66, Texas.** Has 94 miles of 30-in. for *Northern Ontario Pipe Line Crown Corporation* between Hawk Lake and Hyndeman, Ontario.

● **Houston Contracting Company, 2807 Buffalo Speedway, Houston 6, Texas.** Has 43 miles of 12-in. and smaller gas line for *Southern Natural Gas Company* southeast of New Orleans, Louisiana; this is a lay barge and quarter-boat operation. Has 216 miles of 30-in. gas line loops for *Gulf Interstate Gas Company* in the states of Louisiana, Mississippi, and Tennessee.

● **Hallmac Construction Company, 3701 Buffalo Drive, Houston, Texas.** Has undetermined amount of various size pipe to lay for *Pacific Northwest Pipeline Company* for gathering system in Four Corners area. Also has undetermined amount of gathering system line for *El Paso Natural Gas Company* in the Four Corners area.

● **Vaughn and Taylor Construction Company, Inc., P. O. Box 3266, Odessa, Texas.** Has contract for 48 miles of 8, 6, and 4-in. line between Kermit and Goldsmith, Texas, for *El Paso Natural Gas Company*.

● **Engineers Limited Pipeline Company, 225 Bush Street, San Francisco.** Has 106 miles of 24-in. for *Laurel Pipe Line Company* from Booth station, Delaware County, Pennsylvania, to Mechanicsburg.

● **Fulton Banister, Ltd., 625 Northern Hardware Building, Edmonton, Alberta.** Has 100 miles of 18-in. for *Alberta Gas Trunk Line Company, Ltd.*, from Burstall at the Alberta border to Provost, Alberta. Also has 22 miles of gas gathering line in the Provost field for *Provo Gas Producers, Ltd.*, consisting of constructing gathering system and wellhead tie-ins—3 to 12-in. pipe; this gas to be fed to Alberta Gas Trunk Lines. Has contract with *Saskatchewan Power Corporation* for 124 miles of 10-in. line from Steelman to Regina and 38 miles of 12-in. from main line's present terminus at Moose Jaw extending to Regina.

● **Engelking and James, Ltd., Edmonton, Alberta.** Has 88 miles of 14-in., 3.5 miles of 16-in. and a total of 23 miles of various other lines for *Saskatchewan Power Corporation* from and in Success and Hatton gas fields in Saskatchewan.

● **Banister Construction, Ltd., 625 Northern Hardware Bldg., Edmonton, Alberta.** Has undetermined amount of 2 to 6-in. extensions to existing systems in cities and towns in Saskatchewan, plus approximately 5000 consumer service connections, for *Saskatchewan Power Corporation*. Has contract for construction of transmission and distribution system in the town of Wilkie, Saskatchewan, for the *Saskatchewan Power Corporation*.

● **Panama Inc., 1418 Melrose Blvd., Houston, Texas.** Has contract for 362 miles of 16-in. for the *Texas-New Mexico Pipeline Company* from Jal, New Mexico, northwestward. Has 193 miles of 4 to 24-in. line in Mocane and Laverne, Oklahoma, fields for *Colorado Interstate Gas Company*. For *Laurel Pipe Line Company*, 78 miles of 20-in. from Mechanicsburg, Pennsylvania, to Duncansville, 118 miles of 18-in. from the latter point to Aliquippa station, Pennsylvania.

● **Morrison-Shivers, Ltd., Box 1076, Austin, Texas.** Has 48 miles of 30-in. for *Northern Ontario Pipe Line Crown Corporation* between Nipigon and Beardmore. Also has 62 miles of 30-in. for *Trans-Canada Pipe Lines* at North Bay, Ontario.

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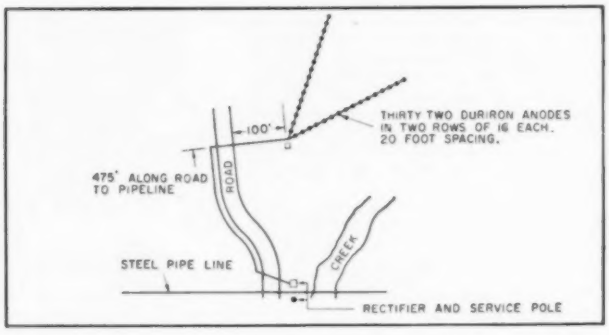
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PIPELINE PERSONALS

Loren K. Kahle has been named transportation coordinator of Standard Oil Company (New Jersey). He succeeds **J. J. Winterbottom,** who recently was elected a vice president and director of Esso Standard Oil Company. **J. M. B. Howard,** assistant transportation coordinator, replaces Kahle as deputy coordinator.

Joe C. Hardin of Little Rock has begun a full-time public relations assignment for The Arkansas Louisiana Gas Company. **Lindsey Hatchett** of Little Rock, an ALG vice president, will be in charge of all gas company operations in the state of Arkansas as of that date.

Hardin, a member of the ALG board since January 1955, and a vice president since January 1956, has been in charge of operations in the Arkansas division. Hatchett, an employee of the company since January 1955, was elected a vice president in January.

Donald A. Robertson, controller and assistant secretary, Panhandle Eastern Pipe Line Company, Kansas City, has been elected a national director of the Controllers Institute of America. The meet was held in conjunction with the 1958 Midwestern Controllers Conference of the Institute.

R. Frank Nowlin, engineer of operations for the Houston division of United Gas Corporation, has been elected general chairman for the 1959 Southwestern Measurement Short Course at the University of Oklahoma. Nowlin is president of the San Jacinto Chapter of the Texas Society of Professional Engineers. He has been with United Gas in engineering capacities since 1940.

Samuel A. Chadwell, chief dispatcher for the Columbia Gas System's natural gas transmission headquarters at Charleston, West Virginia, has retired.

Chadwell, 65, is a veteran of nearly 46 years with Columbia, and with the Ohio Fuel Gas Company. Ohio Fuel is a Columbia subsidiary.

James H. Caldwell has been named to the position of district service manager, Pacific Coast, The Cooper-Bessemer Corporation. In his new capacity as district service manager, Caldwell will be responsible for the supervision of all service activities in the Los Angeles, Seattle, San Francisco and Casper, Wyoming areas.

Clifford E. Bell, superintendent of the Pheonix Lake district of Ohio Oil's Illinois Pipe Line Company of Texas, has been appointed superintendent of the eastern crude oil pipeline section at Lima, Ohio. He succeeds **M. E. Parker,** who was named assistant superintendent of Ohio Oil's Casper (Wyoming) pipe line division.

Dan Williamson, Houston, has been elected a vice president of Transcontinental Gas Pipe Line Corporation. He has been manager of the company's land department since 1953. Williamson joined Transcontinental in 1949 as chief of acquisition when the natural gas pipeline was being constructed from Texas to New York.

J. E. Allison has been elected a vice president of Texas Gas Transmission Corporation. Allison was formerly director of sales and customer relations for the company and in his new position will retain the responsibility for those functions.

William C. Allen Jr. has been newly employed as sales and service engineer with Tod Pazdral Pipe Line Specialists, Houston, Texas. He was formerly an independent consultant and oil operator in San Angelo. Prior to this he had been in the geological department of Magnolia Petroleum Company. He was also a sales and service engineer with Magcobar in the Texas offshore division.

W. C. Allen Jr.

J. F. Simmons

James F. Simmons also is a new Topaz salesman. He was formerly with Oslund Tool and Die Company of Hartford, Connecticut. He is a University of Arizona graduate and was the former office manager of Oslund.

Harold Burrow, veteran senior vice president of the Tennessee Gas Transmission Company, has been designated by the board of directors as first vice president and assistant to the president. Newly-designated senior vice presidents are: **C. C. Johnson,** formerly vice president and treasurer; **Joe J. King,** formerly vice president (engineering development), and **W. W. Witmer,** formerly vice president (gas supply).

Newly-elected vice presidents were: **W. C. Braden Jr.,** formerly director of certificates; **L. W. A. Campbell,** formerly chief engineer; **O. H. Simonds Jr.,** formerly director of sales, and **Stanley Ward,** formerly director of taxes.

The directors re-elected were: **R. K. Hanger, Ardon B. Judd, Eugene McElvaney, Roy S. Nelson, A. Dee Simpson,** Symonds and **Marshall R. Young.** The re-elected company officers include Symonds, president, and **R. R. Dean, N. W. Freeman, R. C. Graham, Charles A. Lingo, W. C. McGee Jr.,** and **R. L. McVey,** senior vice presidents.

Also **E. E. Miller, E. S. Murray, Carl Myers, S. C. Oliphant, Wilton E. Scott, Curtis M. Smith, Louis C. Sonnen, O. W. Ward** and **Stone Wells,** vice presidents; **W. D. Walser,** vice president and controller; **James E. Ivins,** secretary, and **C. S. Taylor Jr.,** general attorney.

H. R. Wall, Continental Oil Company, Houston, Texas, was elected to the board of directors of Platte Pipe Line Company. Wall succeeds **A. W. Tarkington,** also of Continental. Members re-elected to the Platte board include **K. A. Covell,** The Pure Oil Company; **Karl T. Feldman,** Sinclair Pipe Line Company; **R. E. Kepke,** The Toronto Pipe Line Company; **W. L. Kygar,** Continental Pipe Line Company; **J. H. Renard,** Sinclair Pipe Line Company; **Jack H. Rice,** The Ohio Oil Company; **W. G. Sexton,** The Toronto Pipe Line Company, **R. F. Sturgis Jr.,** The Pure Oil Company; **D. R. Williams,** The Ohio Oil Company, and **R. F. Moore,** Platte Pipe Line Company.

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Pipeline Projects

Work Approved for Southern Natural Totals $39,767,800

The Federal Power Commission has issued certificates to Southern Natural Gas Company authorizing a total of approximately 360 miles of pipeline in southern Louisiana as well as 4310 hp in compressor capacity and 23 measuring stations. Total estimated cost of all facilities is $39,767,800.

These facilities, together with others recently authorized by the commission, will increase its south Louisiana supply system by 298,030,000 cu ft per day.

The commission pointed out that the 22.8-cent per mcf initial price to be paid by Southern for the gas will be among the highest for any produced in the southern Louisiana area. In view of this fact, FPC said that it would subsequently institute investigations to determine the reasonableness of the producers' rates.

The commission also said that Southern has not shown the plan of financing the proposed projects, although it has demonstrated its ability to induce capital investments in past construction projects, and therefore conditioned its authorization to require Southern to sumbit a satisfactory financing plan prior to beginning construction of the projects.

Texas Gas Files Budget Type Application

A "budget-type" application by Texas Gas Transmission Corporation, asking authority to construct facilities valued at $3,000,000 has been filed with the Federal Power Commission.

Texas Gas proposes to construct the necessary facilities to enable it to take into its pipeline system natural gas it may purchase from independent producers in the general area of its system. The facilities would be constructed from time to time during a period of 12 months following authorization. The applicant said the cost of any single project would not exceed $400,000.

Pacific Lighting Line to Connect with Transwestern

Pacific Lighting Gas Supply Company has filed an application with the California Public Utilities Commission for authority to build a 128-mile, 34-in. natural gas pipeline from the California-Arizona border near Topock to Newberry, California.

The pipeline would tie in with the 1300-mile system that will be built by the Transwestern Pipeline Company of Houston. Transwestern has filed an application with the Federal Power Commission to build the line from West Texas to the California state line. Pacific Lighting Gas Supply Company, a wholly-owned subsidiary of Pacific Lighting Corporation would bring the gas in from the California border for sale to Southern California Gas Company and Southern Counties Gas Company, other subsidiaries of Pacific Lighting.

When completed in late 1959, Transwestern pipeline will be able to deliver 400,000,000 cu ft of gas a day. Initial deliveries are scheduled at an average of 350,000,000 cu ft a day.

In addition to the pipeline, a compressor station will be built near Needles to push the gas across the state to the coastal population centers. Estimated cost of this line and compressor station is $21,000,000.

NGPL Amended Request Would Increase Expenditure

Natural Gas Pipeline Company of America has amended an application previously filed with the Federal Power Commission to seek authorization for natural gas pipeline facilities estimated to cost approximately $86,158,000.

As originally proposed, the facilities in this application depended on its receiving a certificate in Docket No. G-9966, the company said. By the amendments, the company proposes to revise the sequence and the manner in which the additional facilities applied for in both applications are to be constructed and placed in service.

By the amended application (G-12,-399), Natural proposes to construct about 232 miles of 36-in. loop line between Joliet, Illinois, and Beatrice, Nebraska, in lieu of about 59 miles; about 258 miles of 36-in. and 21 miles of 26-in. loop line between Fritch, Texas, and Beatrice, in lieu of about 337 miles of 30-in. line; two new compressor stations in Texas and Oklahoma, with a combined installation of 12,285 hp; and metering facilities as originally proposed. Part of these facilities were included by Natural in its application in Docket No. G-9966.

Omitted from the facilities originally proposed are additions of compressor horsepower in four existing stations. Cost of the facilities as initially proposed was estimated at approximately $62,668,000.

Jet Fuel Line to be Laid at Savannah

Construction of a jet fuel pipeline to service Hunter Air Force Base from the Savannah, Georgia, port has been announced.

The new 6-in. pipeline, approximately 9.5 miles in length, will cut across this city in a southwesterly direction to serve the Air Force with a minimum of approximately 300,000 gal of jet fuel per day.

Vice Admiral W. J. Carter, Ret., vice president of the Onego Corporation's Georgia Pipe Line Company, said that the Georgia Port Authority, headed by Bob Frankenfield, will administer and operate the pipeline on a fee and royalty basis.

The line will be built by the Standard Corporation of Houston, Texas, at a cost of approximately $300,000.

$48,632,000 Involved In Two Gas Projects

Federal Power Commission Presiding Examiner Glen R. Law has filed an initial decision, subject to review by the commission, authorizing Texas Eastern Transmission Corporation to construct 59 miles of 30-in. and 22 miles of 41 in. line, 141,780 additional hp in existing compressor stations, and a new 2200 hp compressor station, in Louisiana, Mississippi, Pennsylvania, Ohio, Kentucky, and Tennessee. Estimated cost of facilities is $37,435,000.

The presiding examiner also granted Texas Eastern, Penn-Jersey Transmission Corporation, an affiliate, authority to add approximately 4000 hp to its Delmont, Pennsylvania, compressor station and to construct five new compressor stations in Pennsylvania with a total capacity of 67,000 hp. Estimated cost of Penn-Jersey's facilities is $11,-197,000. Penn-Jersey's facilities will be leased to and operated by Texas Eastern.

New Lines, Wells for Michigan Gas Storage

With approval of the Federal Power Commission, Michigan Gas Storage Company will construct 40 miles of 26-in. pipeline, extending from a point in Gratiot County to Isabella County, drill 25 wells in the Winter field and Cranberry Lake storage field, and lay field lines to connect the new wells to the undergound storage. Total cost is estimated at $3,990,000.

Texas Illinois Plans Increase In Capacity

A $3,915,000 expansion project to bring an additional 20,000,000 cu ft of natural gas to its market area by the end of the year is proposed by Texas Illinois Natural Gas Pipeline Company.

The company has filed an application with the Federal Power Commission for the project designed to increase the daily deliverability capacity of its system to 524,000,000 cu ft.

The increase in daily capacity would be accomplished by the installation of one additional 2000-hp compressor engine at eight of the company's 11 compressor stations, including Lufkin and Marshall, Texas; Texarkana, Malvern, Searcy, and Biggers, Arkansas; Jackson, Missouri; and Hammond, Illinois.

Line From Swan Hills To Edmonton Finalized

Federated Pipe Lines, Ltd., has received an Alberta Government permit to construct 125-mile 10-in. crude oil pipeline from the Swan Hills oil pool to Edmonton. Bids are to be asked in time for an early summer construction start and early fall completion.

Another application also has been filed, by Peace River Oil Pipe Line Company, for a line to run southwest from the same pool to join its own main line at Iosegun Junction, south of the Sturgeon Lake oil fields. The line would be 6 in. for about 25 miles southwest to the Virginia Hills pool, 8 in. another 25 miles to Windfall, where a short lateral would cross the Athabaska River to tie-in the Windfall oil pool, and 12 in. for the remaining 30 miles west by north to the junction. The producer-owned line at present is carrying only one-third to one-quarter capacity and is anxious to get more throughput.

Texas Eastern Constructing LPG Underground Storage

Construction of an underground storage cavern for liquefied petroleum gas at Lebanon, Ohio, 30 miles north of Cincinnati, has been started by Texas Eastern Transmission Corporation. The cavern is on an 89-acre tract, which will be known as the Todhunter Terminal.

When in operation the Todhunter Terminal will be used to store and distribute LPG by truck and rail transport over a wide range of states from Michigan to New England. LPG will be transported to the terminal from Gulf Coast origins through Texas Eastern's Little Big Inch petroleum products pipeline system.

The cavern is being mined out of a stratum of gray shale lying about 350 ft beneath the surface of the Todhunter site. Construction began with the drilling of a vertical shaft to the required depth. Next a steel casing 42 in. in diam will be cemented inside the shaft. Miners will open a small room in the shale at the base of the shaft. A large high-lift bulldozer will then be dismantled on the surface, lowered piece by piece, and reassembled in this room. Using specialized mining tools, corridors approximately 15 ft wide and 20 ft high will be turnneled into the shale until the required volume of space has been mined out. Only one-third of the shale will be tunneled out; the remaining two-thirds will be left behind in walls and pillars to preclude any possibility of roof-fall or cave-in.

When completed, the first cavern at the Todhunter Terminal site will hold more than 12,000,000 gal of LPG, Millard K. Neptune, executive vice president of Texas Eastern's petroleum products activities, said. There is sufficient land at the site to permit the construction of eight other caverns of the same size. Terminal facilities also will be constructed to refine and filter the LPG before it is loaded into railway tank cars and transport trucks.

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It's New Pipeline Equipment

Pipeline Pump With Gas Turbine Drive

The first high-speed pipeline pump to use a combustion gas turbine drive for continuous, remote operation has been announced by Byron Jackson Pumps.

According to N. D. Jesse, vice president and sales manager of engineered pump products, the high-speed turbines are fueled by crude oil directly from the pipeline, and develop 500 hp to drive the pumps at 5250 rpm.

This compact, simplified design has been developed to provide long operation without maintenance in remote areas, or where reliability is of prime importance. An extra-heavy "stiff" shaft with a low bearing span-to-shaft diameter ratio of 9.3 results in a static deflection of less than .003.

Wearing clearances are .020 in., and the pump can actually be run dry, if necessary, without damage. A Stellite coating on wearing surfaces eliminates the need for impeller wear rings. The pump is a single-stage, double volute, and double suction design. *Byron Jackson Pumps, Inc., subsidiary of Borg-Warner Corporation.*

Circle number (81) on reply card.

Split Channel Conversion Kits

Simple, low cost conversion kits will adapt any Motorola mobile two-way radiophone sold since 1949 to full split channel operation, the company announced in reporting availability of a full line of such kits.

Motorola, since 1949, has anticipated eventual split channel requirements and has designed its equipment accordingly, including such refinements as the patented adjustable "Instantaneous Deviation Control" (I.D.C.) circuit, use of oven type crystals, and interchangeable "Permakay" filters in its mobile and base station radio units.

Estimated conversion time for an average technician is a maximum of 20 minutes for any Motorola mobile or base station model with a minimum of test equipment and shop facilities. *Motorola, Incorporated.*

Circle number (82) on reply card.

Tractor Powered by High Speed Gas Turbine

An experimental crawler tractor powered by a high speed gas turbine is disclosed by Allis-Chalmers. Inside the tractor's engine compartment, a Boeing 502-10C gas turbine power unit has replaced the conventional diesel engine in this early experimental version of what may be the crawler tractor of the future. The experimental model, named the P-91, has been assembled for purposes of research, they report.

The design of the gas turbine involves the equivalent of a "built-in" torque converter, which is standard equipment on model HD-21 crawler tractor. Ability of the turbine to deliver the range of speed and flexibility of power required for successful tractor operation will be thoroughly tested and evaluated as Allis-Chalmers continues this far-reaching research program.

Net horsepower developed by the turbine to drive the tractor is said to equal that of its diesel counterpart. The external appearance of the experimental P-91 differs little from today's current model of the HD-21.

According to the company, exhaust gases while greater in volume have been handled in such a way as to avoid any inconvenience to the operator. Noise level of the experimental unit is reported to be equal to the diesel powered unit, although the pitch and character of the sound is entirely different. *Allis-Chalmers Manufacturing Company.*

Circle number (83) on reply card.

Portable Transmitter-Receiver

General Electric has entered the hand-carried two-way radio market with a portable transmitter-receiver described as

a new breakthrough in the technology of transistorization. The new product features the country's first tubeless receiver for use in VHF mobile communications services. It will be especially valuable to pipeline and utility companies in inspection work done by crews patrolling pipelines and wire lines to check for damage. *Communications Products Dept., General Electric Company.*

Circle number (84) on reply card.

New Concept in Motor Design

A new concept in the design of large a-c motors is announced by Westinghouse. The new motor design, called F/A (fully accessible) motor, permits the enclosure to be manufactured independent of the wound stator. Now, during assembly, the enclosure is merely bolted to the base of the motor making the wound stator fully accessible when required. Previously, the enclosure was welded or cast as part of the wound stator, limiting accessibility.

As a result, the complete line of Westinghouse squirrel-cage, wound rotor, and synchronous motors from 250 to 7000 hp (depending on speed) for all horizontal utility and industrial drive applications have been redesigned to use only six basic enclosures and 30 frame sizes as compared to the 450 frame sizes formerly used. *Westinghouse Electric Corporation.*

Circle number (85) on reply card.

Low Speed Rotary Air Compressor

A new 365 .fm rotary air compressor speed of only 1100 rpm is announced by the Le Roi Division, Westinghouse Air Brake. The Le Roi 365RD2 is the second of a new line of rotary air compressors. It is a portable, two-stage, oil-cooled, sliding vane type compressor rated at 365 cfm of free air compressed to 100 psi.

The compressor is coupled to a GM 471 diesel engine with a hydraulically actuated clutch. Engine speed at rated output of compressor is 1650 rpm. A 100 percent capacity control matches air supply to the air demand within a pressure range of 10 psi. *Le Roi Division, Westinghouse Air Brake Company.*

Circle number (86) on reply card.

Vertical Hollow Shaft Motors

A complete re-designed line of vertical hollow shaft motors for powering deep and shallow well turbine pumps has been introduced by the electric motor division of A. O. Smith. Offered in a complete range of from 1 to 700 hp to provide the right motor for every turbine pump application, the new line features weather-protected, totally-enclosed, and explosion-proof models. Single-phase models are offered in sizes ranging from 1½ to 5 hp, and polyphase in 1 to 700 hp. Part-winding start models are available in the 20 to 700 hp range. *Electric Motor Division, A. O. Smith Corporation.*

Circle number (87) on reply card.

High Pressure Drilling Machine

An automatic, high pressure drilling machine for making cuts from 2 in. through 6 in. in any type of pipe has been announced by Mueller. The drilling machine, designated the "CH-6," is intended for use on distribution systems, transmission lines, in refineries and chemical plants, as well as other manufacturing plants where connections are required under pressure. It is designed for making cuts into high pressure gas, oil, water, or steam lines. The machine features direct-reading tool position and feed indicators and automatic disengagement of the tool feed. Maximum working pressure of the CH-6 is 1440 psi at 100 F; maximum working temperature is 500 F at 1250 psi. *Mueller Company.*

Circle number (88) on reply card.

Tester Checks Monoxide Level

A low-cost, dual-purpose carbon monoxide tester that makes it possible to detect CO concentrations right in the engine exhaust stream as well as in room atmospheres is being marketed by Oxy-Catalyst.

The direct-reading unit shows at a glance whether carbon monoxide is above or below safe concentration levels and also indicates the approximate percentage concentration. No color-matching or reference to comparator scales is required. The device, called the Oxy-Monoxo, will detect carbon monoxide in the approximate range of 100 to 1000 ppm. *Oxy-Catalyst, Inc.*

Circle number (89) on reply card.

Tractor Has Six Speed Ranges

International Harvester has introduced a new 134-hp diesel crawler tractor, the TD-20. The TD-20 offers a major advance in crawler tractor design in its power class with a 6-speed full reverse transmission. With a single lever, an operator can shift the transmission through 6 speed ranges. A separate lever operates the forward-reverse "shuttle bar" control, which provides 6 speed ranges forward and 6 in reverse.

Because of this unique design, TD-20 operators can make full use of the high reverse speeds available because of the planned shift pattern. When the directional "shuttle bar" shift lever is moved the tractor travels either forward or reverse in any pre-selected speed range.

As a consequence, dozing cycle time is rapidly reduced, the company states, since operators doze forward in second gear and return in third or fifth gear. This can be accomplished by the natural sweep shift hand motion of the tractor operator when changing direction of the tractor. *Construction Equipment Division, International Harvester Company.*

Circle number (90) on reply card.

Tubes for Mobile Communications

Eight new industrial tubes for two-way mobile radio systems operating from 12-v storage batteries are announced by the RCA electron tube division. To give dependable performance when storage batteries are charging and discharging, the heaters of these tubes are designed to withstand an intermittent heater-cycling test of 2000 cycles minimum at high heater voltage. Designed to operate over a heater voltage range of 12 to 15 v, the tubes are subjected during manufacture to rigid controls and tests for heater-cathode leakage, interelectrode leakage, elevated heater-voltage life performance, as well as intermittent short-circuits. *Electron Tube Division, Radio Corporation of America.*

Circle number (91) on reply card.

Non-Lubricated Compressors

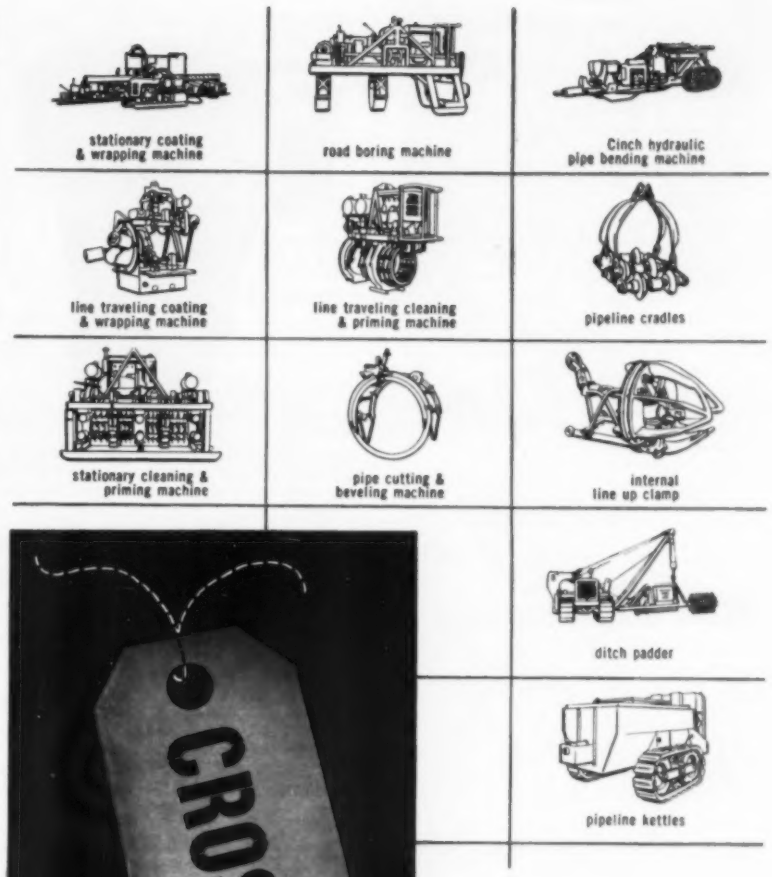
A new line of non-lubricated compressors is being built by Ingersoll-Rand for heavy-duty service where the air or gas being compressed cannot be allowed to contact oil or other lubricants. These new ESH-NL compressors have special compressor cylinders which require no oil or other lubricants, due to use of self-lubricating materials in pistons and packing, as well as Ingersoll-Rand's "NL" channel valves. They use the same frame and running gear as the company's new ESH horizontal compressor, and are also available as vertical units (called ESV). *Ingersoll-Rand.*

Circle number (92) on reply card.

Rear-Hinged Digging Bucket

A choice of bucket styles to fit job requirements is now offered on Model 1000 Case TerraTrac crawler tractor-shovels. In addition to the front-hinged bucket with extra-high dump clearance, said to be ideal for stockpiling and truck loading, etc., a new rear-hinged bucket is now available on the company's 100-hp model for heavy-duty digging. Both buckets are rated at 2 cu yd capacity; however, the new rear-hinge design has more than 25 percent greater breakout force, and about 600 lb greater carrying capacity for handling heavy materials. *J. I. Case Company.*

Circle number (93) on reply card.



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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

New Equipment

Microwave RF Equipment

New microwave RF equipment designed for duplex, multi-channel, point-to-point communications has been announced by Motorola. The new MR-20 incorporates the features of prior Motorola microwave models plus refinements that provide greater reliability and simplicity.

Operating in the 6000-7000 mc band, the equipment is able to utilize high gain, highly directional antennas of reasonable size, permitting reliable operation at conservative transmitter power output.

With major power gain realized in the antenna system, the MR-20 can use low power reflex klystron tubes in the transmitter and receiver. The use of these long-life reflex klystrons permits generation and direct frequency modulation of the microwave carrier in one dependable tube, reducing the number of components needed and adding to the overall reliability of the equipment.

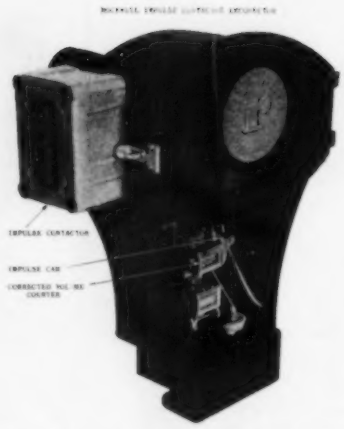
The wide modulation on bandwidth of the MR-20 permits transmission of a practically unlimited number of channels of information. *Motorola, Inc.*

Circle number (94) on reply card.

Electronic Device for Remote Gas Meter Reading

An electronic device that enables field engineers to receive all gas meter readings in one central office, is announced by Rockwell Manufacturing.

Called an "Impulse Contactor," the new device is used in combination with another Rockwell-developed product, the "Emcorector." The Emcorector is a gas meter attachment that utilizes a simple,



accurate integrating mechanism to provide a direct volume reading at base contract pressure without need to correct for line pressure.

When a specified volume of gas — 10, 100, or 1000 cu ft — has been registered by the Emcorector, a gear is engaged that moves a cam to complete an electrical circuit with the Impulse Contactor. With the circuit engaged, a pulse is transmitted to a counter on a central control panel. At the present time one computer is used with each Impulse Contactor. However, an electronic integrator can be installed in the control panel to allow one counter to indicate the total volume from several meters. *Gas Products Division, Rockwell Mfg. Co.*

Circle number (95) on reply card.

'Varec' Time-Data Printer

The Vapor Recovery Systems announces their new time-data printer for use with their pulse code telemetering receiver.

The printer is the parallel entry type, printing one letter as a key to the type of data, two digits for numerical identification of the transmitted element and three digits and a fraction for actual counting entries. A full reading up to 99 ft 11⅞ in. may be recorded. Symbols such as F, #, etc., may replace fractions when desired. The balance of information printed is: Month, day, hour, minute, a.m. or p.m. and year.

The programmer is compatible with any pulse code receiver having data output connections. *Vapor Recovery Systems Company.*

Circle number (96) on reply card.

Floatless Level Controllers

The "PLC" Series Floatless Controller is specifically designed for inlet gas scrubbers on compressors, but may be applied to any liquid level control application in conjunction with a diaphragm type motor valve.

These non-bleed pilots are self contained and have no tubing inside the case. The diaphragm movement is transferred across the pressure barrier by a low friction waggle arm principle.

The pilots have a built-in mercury filled snubber which damoens or reduces effects of pressure pulsations.

PLC pilots are furnished for snap action for use with pressure opening motor valves. For other applications specify type of service desired. *Kimray, Inc.*

Circle number (97) on reply card.

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18"	6' 3"x16"x⅝"	71#	56#	96,000#
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NEW LITERATURE

Hot Spot Protection

A report by Corrosion Services discusses "hot spot" cathodic protection for bare or poorly-coated pipelines. It presents an economic comparison between the use of two kinds of magnesium anodes for this purpose — the standard H-1 alloy anodes and Galvomag anodes, the high-potential magnesium anodes developed by The Dow Chemical Company. *Corrosion Services, Inc.*

Circle number (98) on reply card.

Plastic-Coated Steel Pipe

A newly revised 4-page folder on Republic's new X-Tru-Coat Plastic-Coated Steel Pipe and Tubing has been published by Republic Steel. Recent improvements are covered in the folder. The folder describes the problems of pipeline corrosion, and shows how the strength of steel and the protection of plastic have been combined in a product to meet the requirements of the most severe corrosive applications. *Republic Steel Corporation.*

Circle number (99) on reply card.

Motor Application Guide

Century Electric has issued a new 12-page 1958 Motor Application Guide. The guide is designed to make motor selection easy. Skillful operation of matching motor characteristics and load requirements has been simplified. An application chart provides information on typical driven equipment, character of loads, starting and running torques. *Century Electric Company.*

Circle number (100) on reply card.

Command Performance

"Command Performance" is the title of a new booklet prepared by Caterpillar, to feature components of Caterpillar-built motor graders.

The Caterpillar No. 112 and Cat No. 12 motor graders are presented in center ring fashion in this booklet to display the features. *Caterpillar Tractor Co.*

Circle number (101) on reply card.

Diesel Crawler Tractor

A new 14-page catalog (MS-1289) pointing up features of the HD-16 diesel crawler tractor is available from Allis-Chalmers.

Illustrations and text matter highlight features of the HD-16. A gate fold permits a large cutaway view of both gear transmission and torque converter models. Also a part of MS-1289 is a 2-page spread telling of matched equipment available for this tractor. Specifications are also included. Also available now are two "spec" sheets. *Construction Machinery Division, Allis-Chalmers Manufacturing Company.*

Circle number (102) on reply card.

Industrial Application Bulletin

Schield Bantam Company has announced the availability of a new 2-color, 4-page bulletin outlining applications for its self-propelled Model CR-35 Bantam. Included in the bulletin are 12 money-saving, labor-saving materials handling ideas in the form of actual job reports. The 12 job reports cover everything from a shipbuilding operation to handling pulpwood, unloading automobiles from rail cars to stockpiling, sorting and loading scrap metal and aggregates. *Schield Bantam Company.*

Circle number (103) on reply card.

Link-Belt Speeder Catalog

A new 24-page catalog, No. 2553, covering the full 1-yd LS-98 shovel, crane, dragline, and hoe has been issued by Link-Belt. The catalog, with large photographs and descriptive copy, depicts the LS-98 in detail from the crawler tracks to the upper machinery and the various front end attachments. *Link-Belt Speeder Corporation.*

Circle number (104) on reply card.

Welding Fittings, Forged Flanges

Catalog No. A-101 has been issued by Tube Forgings of America. Profusely illustrated with photos and specification tables, this catalog covers the company's complete line of seamless welding fittings and forged steel flanges. *Tube Forgings of America, Inc.*

Circle number (105) on reply card.

Steel Framework

Three steps in planning, cutting, and joining new Bild-A-Flex steel framework are detailed in a 20-page illustrated catalog entitled "Imagineering in Steel." Bild-A-Flex is used for low cost and quick construction of framework for many industrial uses, from catwalks and machine guards to storage racks and work platforms. The catalog includes tables for calculating maximum loads for horizontal and upright framework. Values are given for lengths of the "L" formed steel in single pieces and combined for greater strength into channels and strips with "T," "U," "Z," and other cross sections. *Berger Division, Republic Steel Corp.*

Circle number (106) on reply card.

Versatility Emphasized

Versatility, combined with ruggedness, are points emphasized in a 12-page catalog released on the Parsons 310 "Trenchliner." The 310, recently re-designed to include many new working advantages, is shown in action on pipeline, irrigation, construction, utility, drainage, and municipal jobs. Capable of handling trenches up to 19 ft deep and 24 to 72 in. wide, the Parsons 310 can carry dual booms-deposit 4 cu yd of spoil per minute. *Parsons Company, division of Koehring Company.*

Circle number (107) on reply card.

Liquid Level Sensor

Technical Bulletin RF-581 by Robertshaw-Fulton describes Betatrol, a high-low liquid level sensor designed to indicate or provide an actuating signal to control or indicate a predetermined level. It operates in water, acids, alkalies, oils, or viscous liquids. *Robertshaw-Fulton Controls Company.*

Circle number (108) on reply card.

Centrifugal Engineering Data

Detailed engineering data and performance characteristics, and a guide to writing specifications, are sections of a new centrifugal compressor catalog being offered by Clark Bros. This 64-page, illustrated catalog includes an introduction to centrifugal compressor features and applications; sections on horizontally and vertically split compressors; and a general section dealing with compressor fundamentals, parts, drivers, engineering data, and specifications. *Clark Bros. Co., one of the Dresser Industries.*

Circle number (109) on reply card.

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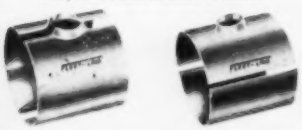

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Canadian News Notes

Interprovincial Awards Pump Station Contracts

Interprovincial Pipe Line Company has awarded construction and supply contracts for its pumping station expansion program. The structural steel and erection for three new bays has been let to Dominion Bridge Company, Ltd., Winnipeg division. The 14 by 72-ft bays will be built onto stations at Regina in Saskatchewan and Cromer and Glenboro in Manitoba. Each will house an eighth pumping unit.

At a fourth station, Glenavon in southeastern Saskatchewan, the seventh pumping unit will be installed in an existing unused bay. Construction of the three new bays and installation of the units in all four stations will be done by Mannix Company, Ltd., Calgary. The units are Dominion Alco 16-cylinder 2040-hp engines driving Bingham pumps through Dominion Engineering speed increasers. Work is to begin immediately, with completion scheduled for September 1 to coincide with completion of main line loop construction contracts.

New Lakehead Station To Be Remotely Controlled

A new fully automatic remotely controlled electric-powered pumping station is to be built at Bay City, Michigan on the United States section of the Interprovincial Pipe Line Company system. Owner and operator is Lakehead Pipe Line Company, Inc., a wholly owned subsidiary.

The station will have four electric motors, three 1750 hp and one 900 hp. It is scheduled for completion and operation next January. A district office and warehouse will be built on the station site, along with maintenance headquarters. The station will be the twentieth on the entire system, which extends 1,930 miles from Redwater, Alberta, to Port Credit, Ontario.

SPC's 1958 Construction Program Totals 468 Miles

A total of 468 miles of main natural gas transmission lines and local distribution systems is involved in the 1958 construction program of Saskatchewan Power Corporation, the provincially-owned company that operates the entire natural gas distribution network in Saskatchewan. The program will increase by 75 percent the existing 674 miles of line, which includes 574 miles of main lines, local mains, and laterals, and 100 miles of gathering lines.

Contracts have been awarded for main line extensions, field gathering systems and wellhead hookups. Total cost is estimated at $9,000,000.

Contract for Unit No. 1 was awarded to Fulton Banister, Ltd., Edmonton. This package includes 124 miles of 10-in. for the main transmission line from the Steelman gas conservation plant, now under construction, to Regina by way of Estevan and Weyburn, and 38.2 miles of 12-in. for extension of the existing main transmission line from its present terminus at Moose Jaw to Regina.

Unit No. 2 was awarded to Engelking and James, Ltd., Edmonton. The largest portion is the main line extension from the Success gas field to the Hatton gas field, on the west side of the province, consisting of 88 miles of 14-in. and 3.5 miles of 16-in. The main line of the Many Islands field gathering system is the second portion, involving 4.5 miles of 16-in. and 17.5 miles of 10-in. The final item is a single mile of 16-in. for the border-crossing link between the two provinces, as the Many Islands gas field is on the Alberta side of the provincial boundary.

Unit No. 3, awarded to Swift Current Construction, Ltd., Swift Current, is 18.1 miles of small diameter pipe for the subsidiary part of the Many Islands gathering system.

Unit No. 4, let to Robb Construction, Ltd., Regina, is 24.8 miles for the Hatton gathering system. Both gathering systems include wellhead hookups.

Alberta Gas Trunk Line Awards Contracts

Contracts for two projects in the second phase of 1958 construction for The Alberta Gas Trunk Line Company, Ltd., have been awarded to Fulton Banister, Ltd., of Edmonton. They include 50 miles of 34-in. to extend the main line from Bindloss Junction to Princess, where the Pincher Creek lateral will join it, and 24 miles of 26-in. for the lateral to take in gas from Cessford and Steveville fields northwest of Princess. A short lateral will be built to Cessford, consisting of 6600 ft of 18-in.

To be let are four more laterals to complete the 1958 program. They are: 11 miles of 6-in. for Sibbald, 5 miles of 6-in. for Buffalo, 1¼ miles of 8-in. for Princess, and 1½ miles of 8-in. for Steveville.

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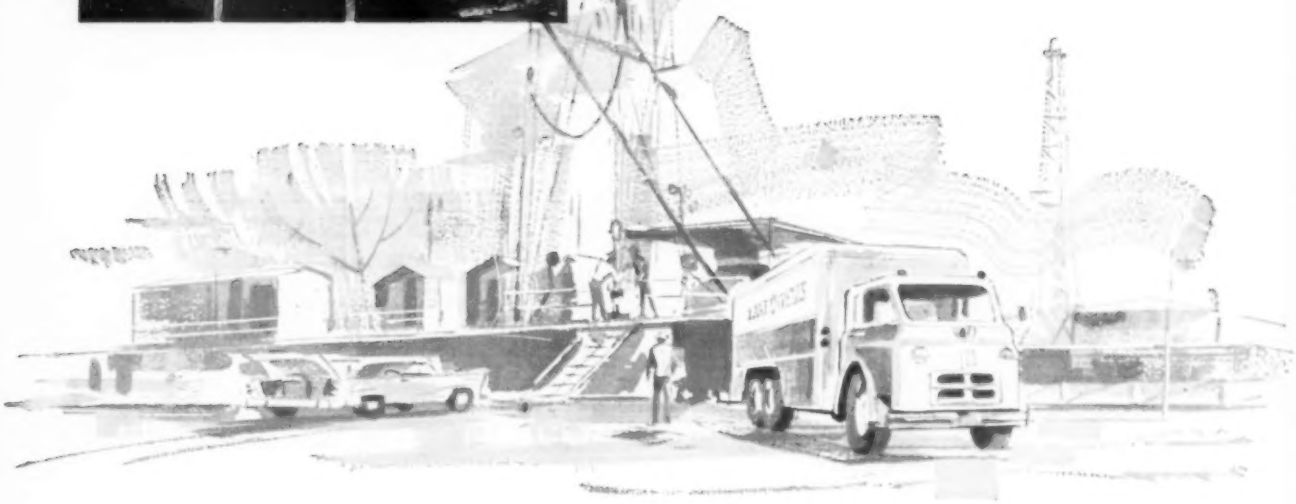

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